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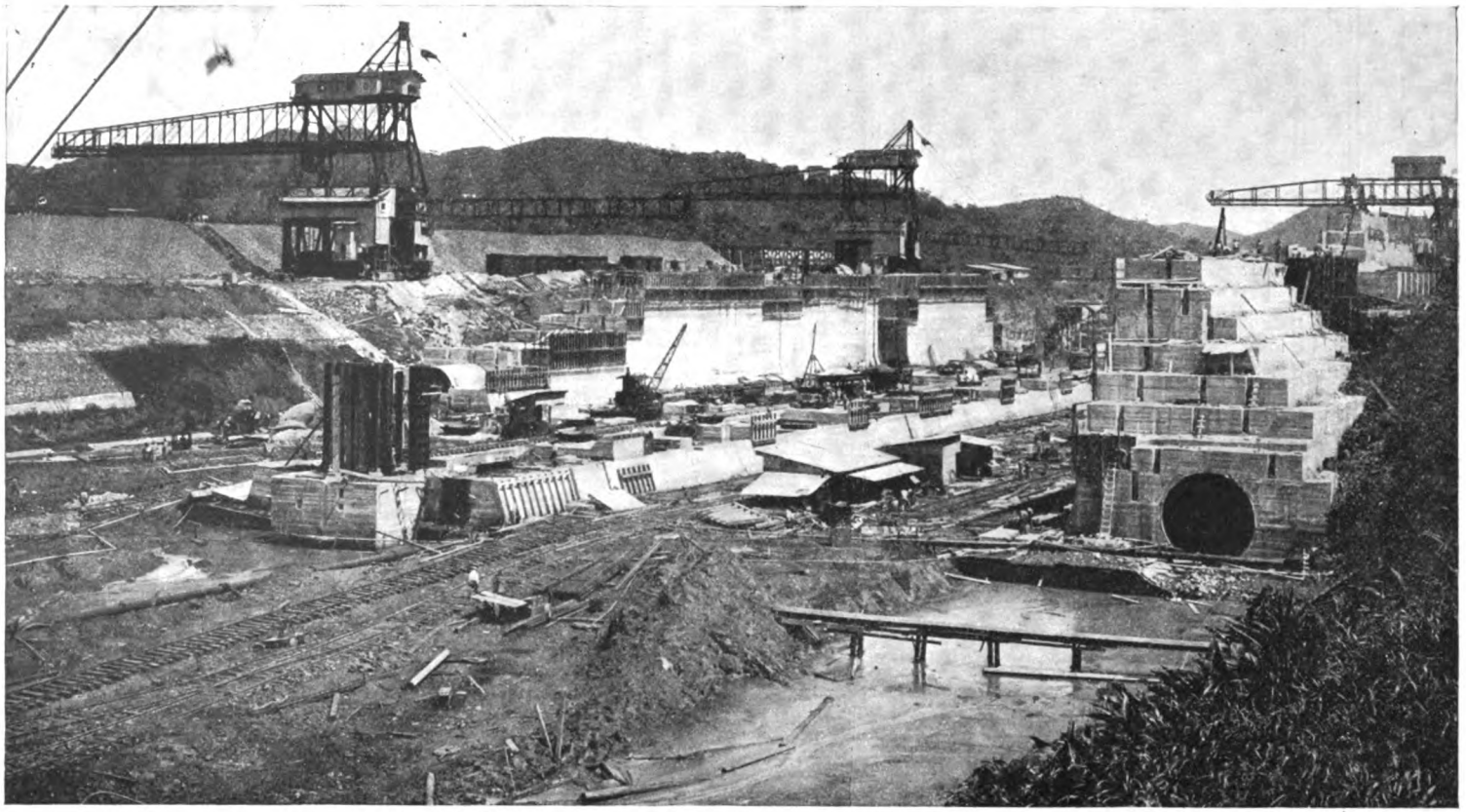

PANAMA CANAL LOCK. THE GATE BETWEEN TWO OCEANS THAT SHUTS OUT ANY STEAMERS MORE THAN 1000 FEET LONG.

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EDITORIAL

'ANALYSIS of Cylinder Performance in Reciprocating Engines,' by Mr. J. Paul Clayton, of which a brief abstract is published in THE ENGINEERING DIGEST of this issue, is worthy of careful study. Mr. Clayton has done a notable work in the preparation of this analysis, and is entitled to the thanks of the entire engineering fraternity. Practicing engineers rarely have the time or facilities for research work, and therefore must necessarily depend upon the various experiment stations and the Government bureaus for fundamental data required in the practice of their profession. The work of the investigating engineer is too often lost sight of in the praise that the world accords for the performance of some specific feat, while no one realizes more than the engineer himself how dependent he is on the class of men who are devoting their lifetime to the study of abstract science.

ELECTROLYTIC decomposition of adjacent objects by the leakage of current from buried conductors because of defective insulation, broken bonds, and other causes, is receiving much attention from engineers. The method for the measurement of stray currents described by Mr. Carl Hering in THE ENGINEERING DIGEST of this issue is evidently the result of much experience, and is worthy of careful study. Mr. Hering, in emphasizing the necessity for making rough mental calculations during the course of the readings in order to be sure that there are no grave errors, wrong connections, or inconsistencies, reminds us of the case of a college professor who was conducting an experiment along similar lines for the benefit of a number of students. Returning to the laboratory after an absence of about an hour, he noticed that one of the connections of the electrical apparatus in use had become detached, thus breaking the circuit. Turning to the students, his surprise may be imagined when he found that they had one and all solemnly and conscientiously recorded a long and unbroken succession of zero readings.

UNSATISFACTORY service is a frequent topic of conversation among the passengers on railway trains. It is a favorite subject with smoking-car orators, so much so, in fact, that one is prone to wonder how they would like to revert to the stage-coach of their forefathers. Occasionally facts are brought to light that point the finger of ridicule at the grumbler, as was the case of a passenger on one of the Southern Pacific overland trains running between Chicago and San Francisco. A little time had been lost between Chicago and Omaha, and from that time on the passenger made the life of the conductor a burden by his interminable questions. He gave out the information that it was imperative that he be in San Francisco in time to make a steamer connection, and consequently the conductor was called upon four or five times a day during the journey across the continent to check and compare time schedules, discuss the possibilities of making up the lost time, etc., while during the intervals between, the passenger regaled his fellow-travelers

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with his opinions of railroads in general and the Southern Pacific Company in particular. It happened that one of the officials of the company was on board the train, and, as on the last day the anxiety of the passenger became acute, the conductor in desperation asked the official for help. The latter, therefore, proceeded to devote his time to the delivery of a lecture on the art of railroading, including a careful discussion of time schedules and the like, and finally asked what steamer the passenger wanted to catch. Upon this the passenger explored his pockets, and after much fumbling brought forth a ticket to Sausalito.

THE Trans-Mississippi Commercial Congress will hold its twenty-third session at Salt Lake City, August 27 to 30. A large number of subjects of special interest to Western engineers will be discussed, among them being 'Good Roads,' 'Immigration,' 'Reclamation of Land by Drainage,' 'Transportation by Rail and Water,' and 'Inland Waterways.' There is probably no organization of a similar character that has done so much for Western states in securing necessary legislation and appropriations from the Federal Government. A notable gathering of men prominently identified with the development of the country will attend the Congress and the result of their deliberations will be awaited with a great deal of interest. Salt Lake City will also be host to the annual convention of the International Irrigation Congress which will hold its session September 30 to October 4. That much information of value and interest will be brought out during the discussions goes without saying, and irrigation will undoubtedly receive fresh impetus as a result of the interchange of ideas among those present. It is to be hoped that California will be well represented at both conventions, as the vast reclaimable area within the state makes reclamation and irrigation paramount.

PANAMA Canal reports indicate that seven-eighths of the project is completed. On June 1, but 22,053,815 cubic yards of rock and earth remained to be excavated. The slides in Culebra cut continue, but they merely serve to deliver earth to the steam-shovels.

ERRORS occur in spite of constant efforts to prevent them. In the INDUSTRIAL PROGRESS section of July *Western Engineering*, on page 335, the photograph of the road in the article entitled 'Fundamentals of Good Roads' should bear the following legend: 'Repairing bituminous-base road in 1911 in King county, Washington.' The photograph on page 336, entitled 'A Finished Road,' should bear the caption: 'A concrete-base road after three years, showing the base in same condition as when first laid.'

MANY engineers are planning to attend the sessions of the Pacific Highway Association, which will meet at the St. Francis hotel Monday, August 5. This promises to be the most interesting session of its kind that has thus far been held on the Pacific Coast. The movement for the building of good roads, now almost universal throughout the United States, is especially strong at present in California and the other Pacific Coast states, which are well to the front in the number of miles of new road projected. The plans of the California Highway Commission contemplate the building of a trunk road which will extend from the Oregon line to San Diego. The counties

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generally will construct the various feeders along the line. The Pacific Highway Association, however, is endeavoring to promote the construction of a trunk line which will extend from Canada to Mexico. The vast amount of good that such a work would do, and the benefits that would accrue to the people as a whole, can hardly be overestimated. A large number of delegates from all the Pacific Coast states will be present, and it is altogether likely that some definite action will be taken toward the construction of such a highway, to be completed by 1915. The number of visitors that will flock to San Francisco during the time of the Exposition, and the almost universal use of the motor car will, in combination with such an international highway, give visitors an opportunity to acquaint themselves with the magnificent possibilities of the West in a way that is not possible by rail travel. That the men interested in the movement appreciate all these conditions goes without saying. California, with an appropriation of $18,000,000 for its system of highways and with construction already under way, is doing her share. It is to be hoped that the other Pacific Coast states will coöperate with the California Highway Commission and that ultimately the Pacific Coast may offer attractions in the way of good roads that will have no superior in the United States.

Railroad Earnings and Wages

Railroad earnings are still steadily tending downward, while wages paid to railroad employees as steadily increase. Reports filed with the Interstate Commerce Commission for the fiscal year 1911, as noted in *Western Engineering* for May, show a net decrease in railway earnings of nearly $41,000,000, while during this same period compensation to employees increased nearly $50,000,000. The decrease in railway earnings per mile for March 1912 was $3, as compared to the same month in 1911. The Bureau of Railway Economics has just announced the result of the compilation of statistics for the 22 months from July 1910 to April 1912. The report states the obvious fact that the earnings per mile form the only correct basis of comparison, as a mere increase in total net operating revenue would give an inaccurate idea of the result of operation if increase or decrease in the total mileage were not taken into consideration. The Bureau reports that the net operating revenue per mile of line for the railways as a whole, in comparison with the corresponding months of the previous year, decreased in eighteen of these months and increased in but four. The decrease per mile of line per month was as great in amount as $53, and as great in ratio as 15 per cent. The greatest increase for any one of the four months showing increases was $31, or 14.1 per cent. This was in February 1912, and was exceptional as this month contained one more day than February 1911. The highest average net operating revenue per mile of line for any one month of this period was $409, the lowest $203. Seven of the ten months from July 1911 to April 1912 show decreases in net operating revenue per mile of line as compared with the corresponding months of the fiscal year ended June 30, 1911; and eleven of the months of the fiscal year which ended June 30, 1911, showed decreases in comparison with the respective corresponding months of the fiscal year ended June 30, 1910. It is, therefore, evident that the trend of railway net revenue has been downward for the

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past two years. The summary for April 1912 shows that net operating revenue was less than for April 1911, by $6,026,-440, equivalent per mile of line to $33, or 11.4 per cent. This net operating revenue, which amounted in the aggregate to $56,362,945, averaged $8.57 for each mile of line for each day in April less by $1.11 than for each day of April last year. This is the gross income per mile of line per day before anything has been taken out for taxes, rentals, interest on bonds, appropriations for betterments, or dividends. Taxes for April amounted to $44 per mile of line, an increase of 9.4 per cent. Coincident with the report of decreased earnings from almost every section of the country is the hearing of the demand for higher wages made by the Brotherhood of Railway Engineers before a board of arbitration now in session in New York. Fifty-two railroads operating east of Chicago are interested in the case, the increase in wages asked for amounting to $7,500,000 annually. The decision of the board will have a far-reaching effect upon the entire country, as many minor disputes between the railroads and their employees which are pending in other sections will probably be settled along the same lines. The railroad companies appear to be situated somewhere between the devil and the deep sea. The Interstate Commerce Commission has shown a pronounced aversion to increased freight rates, and 'revisions downward' are the order of the day. Demands for higher wages on the part of the unions of railway employees are of yearly occurrence, however. The men have everything to gain by arbitration and nothing to lose. The worst that can happen is a return to conditions as they exist at the time the demands for an increase are made, so the men themselves cannot be any worse off than they were before, regardless of what the decision of the board of arbitration may be.

In the meantime, those of us who are neither members of trades unions nor owners of railroads, cannot do other than wonder who holds a brief for the ultimate consumer, who in the end must always pay. Political parties, students of political economy, magazine writers, and the entire country as a whole are giving much thought and discussion to the one issue that affects vitally every individual in the country. The consumers, as a class, outnumber the other two classes many times, and yet, lacking in organization, are impotent and without influence or representation. We have with each session of Congress a plethora of both capitalistic and labor legislation, but where can one find acts formed to protect the consumer from the upper and nether millstones of capital and labor which in truth grind 'exceeding fine'? How novel and interesting it would be, if, for instance, at the sessions of the board of arbitration that is hearing the case of the railroad employees' demand for higher wages, there might be present a representative of the third party to the dispute, the consumer, who might be recognized as having an equal right to be heard with the others. The present tendency toward the concentration of all industrial and public utilities in the hands of a few, together with the increasing power and influence of the trades unions, brings about but one inevitable result as far as the consumer is concerned—a strike followed by an increase in wages paid to labor and an increase in the price of the commodity to cover the difference. The corporation stockholders get their dividends, the workmen their wages, and the consumers the increased cost of living.

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REVIEW OF THE MONTH

MID-SUMMER generally marks a season of rest from the 'strenuous' life and of reversion to mild and gentle pursuits. Among writers, summer is known as the silly season, and it is noted for the class of entertainment served by the proprietors of theatres to the unfortunate summer city dweller. Writers of fiction turn out a type of novel designated in book-stores as 'light' summer reading, while tales of sea-serpents and monsters of the deep are given wide circulation by the industrious press agents for seaside resorts.

THE world moves on, however, as the great majority of men find it just as necessary to deliver a day's work in order to obtain a day's pay in summer as in winter. Certainly no cessation of activity has taken place in the construction of the Los Angeles aqueduct, as the seventh annual report just issued bears witness. The aqueduct is now more than 90 per cent completed, and only a few blocks stand between the end of the line and the Owens river waters. The length of excavation still uncompleted is but 18.99 miles, and of lining 35.05 miles. The report states that unless unforeseen delays occur, the entire work will be completed before March 1, 1913, which will leave ample time for testing the power machinery during the spring months. The financial department states that $5,797,168.39 was spent during the fiscal year ended July 1, and that the total expenditure to date is $20,601,096. Mr. William Mulholland, chief engineer, estimates that the entire project will be completed within the appropriation of $24,500,000, including the purchase of rights-of-way and water rights, although $1,125,000 was spent for covering 100 miles of ditch on the desert and doing extra work in the line of additional power development which was not contemplated in the original plans. It will probably be necessary, however, to sell the machinery, equipment, and stock used in the work in order to come within the appropriation.

RAPID progress has been made on the power tunnels and in preparing the way for the construction of power-houses in San Francisquito canyon. The completed excavation on the power tunnels totals 5.08 miles, and the lining 1634 feet, while 2.53 miles of excavation and 8.01 miles of lining remain uncompleted. A supplementary report has been made by Mr. R. T. Blades, special consulting engineer, retained for the purpose. Mr. Blades was formerly one of the staff of engineers engaged on the Metropolitan aqueduct of Boston, the Croton aqueduct of New York, and in the United States Reclamation Service. Mr. Blades' statement is worthy of note in his praise for the ability and skill displayed by the men in charge of engineering and construction. He states that the work done on the Los Angeles aqueduct, including tunneling, excavating, concreting, and plastering, is superior to that done on both the Croton and Metropolitan aqueducts, and further that it is as good as it is possible for such work to be.

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We are glad to add our measure of praise and appreciation for the splendid work done by Messrs. Mulholland, Lippincott, and their associates, and participate in the pride that is felt by all of the people of the West in the successful consummation of the most notable piece of engineering work that has ever been attempted on the Pacific Coast of the United States.

'TILLMAN'S terror,' the proposed greatest battleship that is being considered at Washington, raises again the question of the size of ocean vessels, discussed in our May number. In the absence of international agreements the only effective limitation on the growth of ocean steamers and battleships is that imposed by harbor and canal facilities. For many years to come it is probable that the size of the locks on the Panama canal will be the deciding feature. In our frontispiece this month we show one of these great locks under construction. As the usable length is 1000, the breadth 110, and the depth 41.5 feet, we are inclined strongly to the current conviction that they are quite large enough. Neither necessity nor economy points to larger ships than can be handled through such a lock.

SOCIAL intercourse among engineers has received impetus in the formation of the Engineers Club of San Francisco at a meeting held at the Palace hotel on July 9. Fifteen San Francisco men were in attendance, representing all of the engineering professions, and after the adoption of by-laws, C. W. Merrill was elected president, A. H. Babcock and M. H. Peck, vice-presidents, A. M. Hunt, treasurer, and H. Foster Bain, secretary. It is the present purpose to meet as a lunch club at noon every Tuesday at the Palace hotel, and ultimately, as the membership grows, for the club to occupy its own quarters and furnish its members with the usual club conveniences. The membership already enrolled numbers over sixty, and it is hoped to make the organization a medium for offering suitable hospitality to visiting engineers especially in 1915.

AMERICAN dollars are to have a further part in the upbuilding of the new Chinese Republic. Mr. Robert Dollar, the well known steamship owner of San Francisco, has agreed to finance a loan of $17,000,000 which is to be used for reconstructing the city of Hankow. The funds in question will be used for the purpose of rebuilding and widening the streets within the native city, the purchase of necessary land, the reconstruction of levees to prevent further encroachment of the river, and the installation of an electric street railroad system, which is to be owned and operated by the government. The provincial revenues are said to have been pledged as security for the loan. The scheme as presented is an undertaking both novel and of unusual magnitude. A business house whose activities have heretofore been confined to the lumber and shipping trade, the Robert Dollar Company is composed of shrewd business men well acquainted with China, and their undertaking to float this loan is a strong endorsement of the new order in the old 'Empire.'

THE fourth annual session of the Pacific Logging Congress held at Tacoma, Washington, July 25, was made up of a notable gathering of men interested in the development of the lumber industry on the Pacific Coast. The Congress is composed of representatives

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from California, Oregon, Washington, Idaho, Montana, and British Columbia, and has for its primary object the dissemination of information and discussion of topics incidental to the logging industry. The control or regulation of prices is not considered, attention being instead centred on questions of greater efficiency in management, the conservation of the available supply, and the engineering features of the industry. Many notable papers of great interest were read, abstracts from some of which will appear in a later issue of *Western Engineering*.

GREAT BRITAIN has taken exception to the bill now pending before the United States Senate with regard to tolls at the Panama canal, on the ground that it violates the Hay-Pauncefote treaty. Provisions contained in the Senate bill in question, and agreed upon by the House of Representatives, provides that American coastwise vessels may use the canal without the payment of tolls. It is generally understood that Great Britain's protest is on behalf of Canadian railroads whose ships, by this provision, would be barred from using the canal except upon payment of the same tolls that would be paid by ocean-going carriers. The Canadian Pacific railroad is operated under a government subsidy and is naturally in close relations with the government itself. It owns and operates ships on both the Atlantic and Pacific oceans, and has naturally anticipated an extensive use of the Panama canal for handling traffic between the Atlantic and Pacific seaboards in connection with the rail lines. If the provision barring ships owned by railroad companies should be finally enacted into law, the steamers owned by the Canadian Pacific railroad would be barred absolutely from participating in the benefits to be derived from the use of the canal, as would also the vessels of the Pacific Mail Steamship Company which is controlled by the Harriman railroad interests. Published interviews with a number of the most influential United States Senators show a variety of opinions as to the justice of Great Britain's claim. It is likely, however, judging by the political complexion of both Senate and House and the imminence of the presidential campaign, that the request of Great Britain will ultimately be denied and that the adjustment of tolls will discriminate in favor of American coastwise ships. Opinions have been expressed that the United States would in all likelihood lose if the case were carried to the Hague tribunal, as the majority of representatives of the various European governments would undoubtedly sympathize with the position taken by Great Britain.

CONDITIONS in Mexico have improved greatly, and in many districts conditions are approaching normal. The Mexican National Railroad Company is continuing construction work on various branches throughout the Republic, the total mileage now under process of completion being 1116 miles or 1935 kilometres. The work under construction includes a line from Durango to Canitas, with a branch to Sombrerete, 172 miles; line from Durango to Llano Grande, 63 miles; line from Penjamo to Ajuno, 87 miles; branch from San Andres Tuxtla, 45 miles; branch from Cerro Colorado, 32 miles; short line from Veracruz to Tampico, with branch to Honey, 379 miles; line from Tampico to Matamoros, 264 miles; line from Allende to Las Vacas, 74 miles. The branch line from Duran-

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go to Llano Grande has the highest bridge in the Republic, crossing the Rio Chico, 56 kilometres west of Durango. It is expected that this branch will be completed and open for operation by the first of October. The branch from Panjamo to San Andres Tuxtla will be finished by November next. The National lines are spending altogether approximately $28,000,000 for the construction of the new lines cited above, their calculations being based upon an expenditure of $25,000 per mile.

REPORTED failure of the California Consolidated Oil Company is a sad commentary on the misuse of great names in the personnel of boards of directors. Admiral Robley D. Evans, whose record in the Navy has endeared him to the hearts of all Americans, was exploited by his associates for stock-selling purposes. The corporation was formed with a capital stock of ten millions of dollars and at the time of the wind-up of the company's affairs but $29 remained in the treasury. The stockholders' meeting, at which the company was dissolved, was attended by the usual number of people of small means who had invested their little all in the company on the strength of Admiral Evans' name. There is no doubt that the condition of affairs contributed very largely to his death and it is hoped that the lesson will not soon be forgotten. It has long been a custom in Great Britain and elsewhere to pad the directorates for all sorts of promotion schemes with titled nonentities in the hope and expectation that such a generous collection of the aristocracy will charm the dollars from the pockets of the working class. This principle is in a fair way of becoming unpopular in Great Britain, as the lawsuits that have been instituted against some of the titled directors are bringing home to the latter the fact that the position of director in a company carries with it responsibilities and duties to stockholders as well as the opportunity to get a slice of promotion stock at no cost.

ENGINEERS owe much to the various bureaus of research conducted by the National Government, and those in active practice are dependent to a great extent upon such organizations for fundamental data. The National Bureau of Standards, which has already done such excellent work, is now expanding the general investigation of structural materials begun originally by the United States Geological Survey, and is making extensive determinations of the physical properties of concrete. The work began in 1904 at St. Louis and included the careful study of the strength of reinforced concrete beams. Later it was transferred to the Bureau of Standards. In the new tests cracking in concrete structures and the expansion and contracting of joints are receiving special attention. Reference marks have been placed upon some of the typical old and new concrete work in Wayne county, Michigan, and at Greenwich, Connecticut. Measurements will be taken from time to time during the summer and winter to determine the expansion or contraction in the concrete caused by temperature variations and the changes of form which take place during the hardening of the concrete. Similar reference marks are being placed in the lock walls of the Panama canal and various other structures. Much valuable data will be obtained in this way and will be the subject of a bulletin that will be issued by the Bureau of Standards as soon as results have been obtained and tabulated

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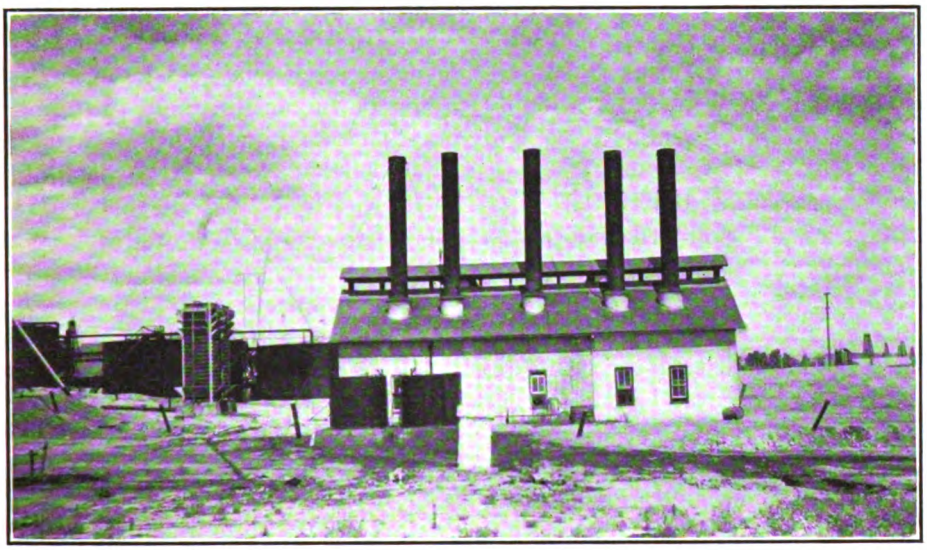
Oil-Pumping Practice at Bakersfield

By CHARLES T. HUTCHINSON

ENCROACHMENT of water in the oilfield is a serious problem, with which all operating companies have to contend. The effect of infiltrating presents itself differently in each district, and from a study of conditions obtaining in the various California fields, it is obvious that corrective methods must be determined and applied to suit each individual case. An exhaustive study of the whole situation has been presented by W. H. Storms and Paul Prutzman in *Western Engineering* for May 1912, in which it is stated that: "In the Kern River field the wells are shallow, and as they were punched down without regard to results, the entire field is wet. Great efforts have been made to shut off the water, but generally without satisfactory results, and the only successful work has been due to the system of pumping by compressed air." The annual report of the Associated Oil Co. for 1911 states that the operation of the high-duty compressors placed in the Kern River field not only checked the encroachment of water, but reduced the general water-level as well. Their operation also reduced the average cost of oil produced 4.6% as compared to that of the preceding year. It is with the installation and operation of the Associated Oil Co.'s compressor plant that this article will deal, and in order that the economies in operation as well as the effect on the wells may be clearly understood, a detailed description will



EXTERIOR ASSOCIATED OIL CO.'S COMPRESSOR PLANT.

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be given. Especial acknowledgments are due to Arthur F. L. Bell, chief engineer and field manager; J. L. Bruce, superintendent of the Kern River district; A. E. Roe, field engineer, and L. T. Andrews, general foreman of power plants of the Associated Oil Co.; Messrs. Peterson and Crites of the Peerless Oil Co.; and E. A. Rix, of San Francisco, for many courtesies and data for the preparation of this article.

Three high-duty compressor-plants in all have been built, at a total cost of approximately $200,000. The largest is of 4000-cu. ft. free-air capacity, and the other two of 2000-cu. ft. free-air capacity each. As they differ from one another only in size, the description of the largest, known as plant No. 36, will suffice.

The compressors used are a type specially developed for oil-well service, and were built by the Laidlaw-Dunn-Gordon Co. Two 2000-cu. ft. steam-actuated machines, with cross-compound Corliss steam cylinders and twin-tandem, two-stage air cylinders, were installed. The two steam cylinders are 17 in. and 36 in. diam.; the four air cylinders are in pairs, of 9½ and 19½ in. diam.; the stroke is 36 in.; the normal full-load speed is 80 r.p.m.; and the horse-power developed 650 for each machine. The working steam-pressure is 150 lb. initial, which, with 26 to 28 inches vacuum, compresses the air to 200 lb. gauge pressure. At the time of my visit, the compressors were running at 82 r.p.m., 155 lb. initial steam pressure, and 22½ in. of vacuum. The vacuum maintained by the condensers under normal conditions is from 26 to 28 inches, but when the reading was taken from the gauges, one of the two 1200-sq. ft. Wheeler surface condensers was having its regular monthly overhauling, and the other was doing double duty, taking the exhaust from both compressors.

The intercoolers are superimposed over each set of tandem high and low-pressure air cylinders, making each half independent of the other. This permits the operation of one-half of the compressor in case there should be occasion to make repairs to the other half. 'Cincinnati' air gear is used, the action of which is so well known as to require no description here.

Boiler equipment includes five Stirling type E water-tube boilers, 207-hp. rating each, working pressure 160 lb. Three of these are in constant use and generate sufficient steam for the operation of the entire plant, including all auxiliaries and a 75-kw. lighting set. One boiler is kept with steam up in readiness to be placed in commission in case of emergency, and one is cold. Two Wheeler surface condensers take the exhaust from both compressors, the lighting set, and the auxiliaries. They have 1200 sq. ft. of cooling surface each and are equipped with the usual air and circulating pumps. As mentioned above, one condenser will take the entire load in case of emergency, and maintain 22½ in. of vacuum. A 75-kw. lighting set consisting of an American Ball high-speed automatic cut-off engine, direct connected to a Westinghouse 240-r.p.m., 3-phase, 60-cycle, 2200-volt, A. C. generator, provides for lighting the entire Associated camp, the load at present including 1600 16-cp. lamps.

An air-receiver was installed, but outside of its value as a trap for the collection of moisture, it is superfluous, as the large air-mains leading from the compressor plant to the various wells afford sufficient receiver capacity in themselves. All steam and hot-water pipes are protected with asbestos pipe-

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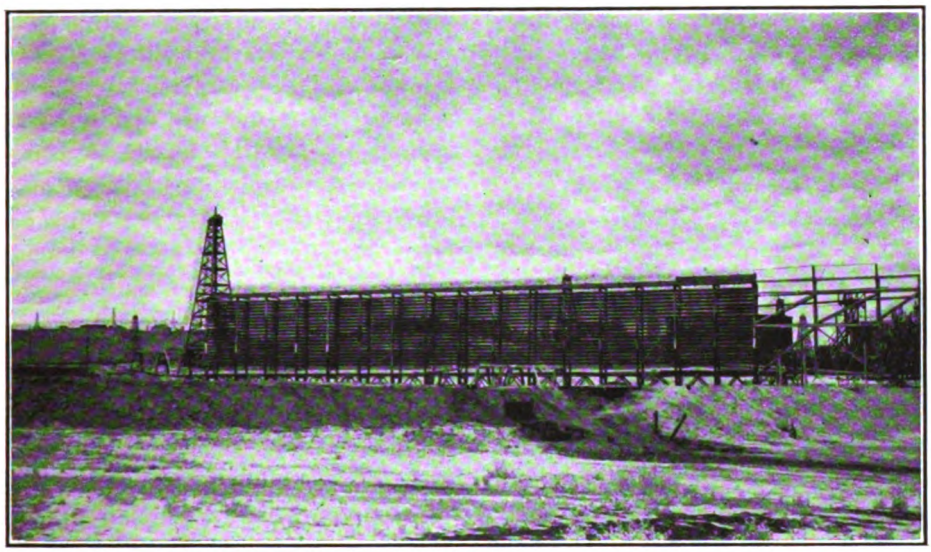
covering in order to minimize the losses due to condensation and radiation. All lubricating oil is carefully filtered to remove any sediment or foreign matter that might affect the operation of the plant at the highest possible efficiency.

A visitor entering any of the Associated Oil Co.'s power plants in the Kern River field is impressed with their thorough cleanliness. Concrete or bituminous macadam is used for floors. In case of the latter, the floor is sanded. The concrete floors present an air of having been freshly swept and scrubbed. There are no remote or dark corners utilized as storage places for sweepings. The interior of every power-house would serve as an illustration of 'Spotless Town.' It goes without saying that there are no steam or oil leaks, neither is there any waste of labor or material. There is an air of satisfaction and pride on the part of the men in charge. They appreciate the fact that they have what is probably the best-engineered, best-equipped plant in the oilfield. They know that it is capable of doing its work with maximum efficiency, that it represents a large capital investment, and that having succeeded in getting the authority for its construction, it rests with them to show a record in reduction in operating expense.

The cooling-tower for the condenser circulating-water is unique. It is 6 ft. wide and 160 ft. long. There are 20 tiers 12 in. apart, placed horizontally on a frame of 4 by 4-in. posts and beams. The tiers are a latticework with 1 in. square interstices made of common lath, nailed to the frame. The hot water is led to the top of the cooling tower through a 6-in. pipe. This pipe extends throughout the entire length of the cooling-tower with spray nozzles every 6 ft. leading downward. The nozzles throw the water out in a fanlike spray which percolates downward through the 20 tiers of lath latticework until it is discharged into the cooling pond below the tower. The temperature of the water as it enters the tower is 110°F. When it discharges



COOLING TOWER AT ASSOCIATED OIL CO.'S PLANT No. 36.

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into the pond it has been reduced to 78°F. The cost of the cooling-tower installed was $900.

The reduction in operating expense of this plant as compared to that of the single-stage non-condensing compressor plants equipped with the ordinary return tubular boilers is striking. The fuel consumption alone is reduced about 40%, the steam consumption under average conditions being 17 lb. per indicated horse-power-hour, requiring 1⅜ lb. of low-gravity oil (12 to 13°B.) per horse-power-hour. Hammel burners are used, taking live steam from the boilers for atomizing. Two fuel-oil tanks are placed just outside of the power-house, the daily consumption being carefully measured and reported to the superintendent. Cards are taken of both steam and air cylinders at regular intervals. Thus accurate records of the performance of the plant form the basis of reports to the San Francisco office of the company.

Before touching upon the application of the air-lift to pumping oil, a brief description of the method of pumping by steam will be given. Steam is supplied from central boiler-plants. Each of these consists of six 70-hp. horizontal return-tubular boilers, of which one is held in reserve. The working pressure is 100 lb., and in order to reduce the inevitably large radiation and condensation losses due to the transmission of steam through pipes over large distances, superheaters are placed in each boiler plant. Natural gas is used for fuel in the superheaters, the steam being turned into the pipes at 540°F. An instance of the ingenuity of the operatives is the utilization of oil-sand as a material for heat insulation. All live-steam pipes laid underground are packed in 6 in. of oil-sand. This sand not only forms an effective insulation against condensation and radiation losses, but prevents external rust and corrosion of the pipe itself. A section of pipe was taken up after having been in service several years, and the exterior surface presented the same appearance as it did when laid. Even the stenciled shipping mark showed as plainly as on the day when the pipe was received on the ground.

Another instance of careful attention to detail is found in the method of lubrication. Each oil pumping engine had been equipped with an individual sight-feed lubricator, which required attention at regular intervals. As an experiment, a central lubricating system was installed at the boiler-plant which sent out all steam with its proper proportion of cylinder lubricant. The result was a saving of 50% in the quantity of oil consumed and 75% in the cost of upkeep in steam lines. Dampers were placed in all smokestacks, thus diminishing the temperature of the flue gases and making a saving in fuel consumption sufficient to pay operating cost for the boiler-plant. The steam oil-pumping engines are the usual 15-hp., 9 by 12-in., horizontal slide-valve type, with link reversing-gear. The fly-wheels are fitted with automatic centrifugal tripper lever acting direct on the throttle valve to shut down the engine in case of accident to the pumping rig. Power is transmitted to the pump by means of the standard calf and bull-wheel, counterbalanced jack outfit. The pumps have 2¾-in. plungers and a stroke adjustable between 18 and 36 inches.

In order to cope with the water situation, recourse must first be had to the logs of the wells themselves. A group of adjacent wells is taken, and the direction of pitch of both the oil-sand and water-gravel strata is deter-

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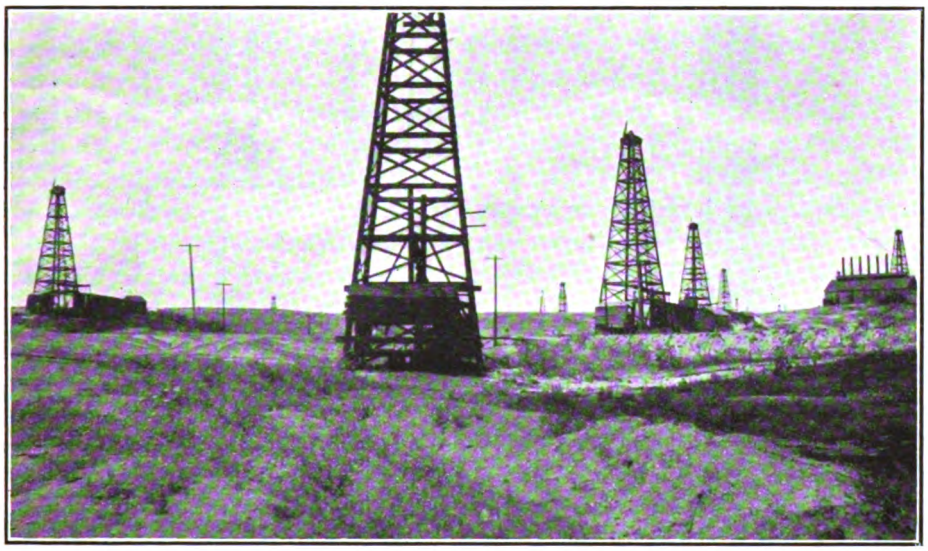
mined with regard to the depth of each well. Thus the direction of drainage of both water and oil is ascertained, and the well or wells designated that would collect the natural drainage of water in the group of wells that are under observation. These are called 'key' wells, as they form the key to the situation so far as the control of water is concerned. The oil and water in the wells naturally stratify, the oil on top. It is obvious, then, that if a



GROUP OF WELLS, ASSOCIATED OIL CO., SHOWING 'KEY' WELL IN THE FOREGROUND.

means of draining the wells of water from below could be provided, the wells could be drained of the water and the oil pumped to the surface without commingling the two and forming an emulsion, the after-separation of which is difficult and costly. As an illustration of how this works, one group of five wells may be cited which was placed under observation and the key well determined. That done, an air-lift was placed in operation pumping water only and was so successful in draining the others of the group that the aggregate production was increased from 50 bbl. per day before the installation of the air-lift pump to nearly 700 bbl. per day afterward. The peculiar fitness of the air-lift for this work places it thus far without a rival. It must be remembered that a pumping device to meet the conditions must occupy a space perhaps not exceeding 6 in. diameter, it must be capable of handling a large volume of water from a great depth, it must be extremely flexible in its range of adjustment for quantity handled and operating head. The ordinary plunger-pump used for oil-well pumping was entirely inadequate, and no relief was in sight for the oil producers until the advent of the high-duty air-lift proved to be a solution of the problem.

The separation between the oil and water that takes place in the wells is not perfect. Neither is it possible, by using the key well for pumping the water only, to drain the other wells of all the water they make. The water will still contain some oil and the oil some water; the difference is in the percentage of water contained in the

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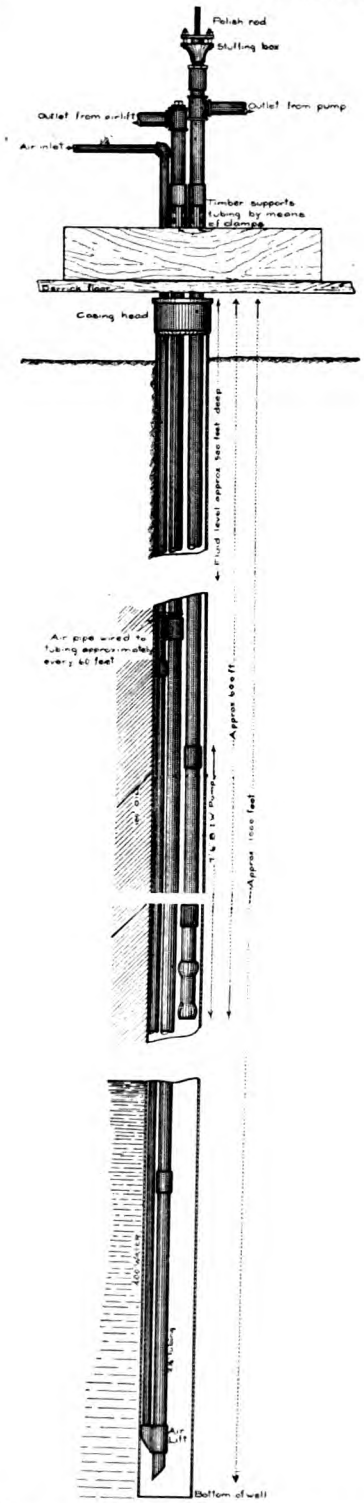

FIG. 1. GENERAL ARRANGEMENT OF PUMP AND AIR-LIFT, ASSOCIATED OIL CO.

oil as it is pumped from the well.

Fig. 1 shows both the air-lift and ordinary plunger-pump installed in a well. Fig. 2 shows a detail of the

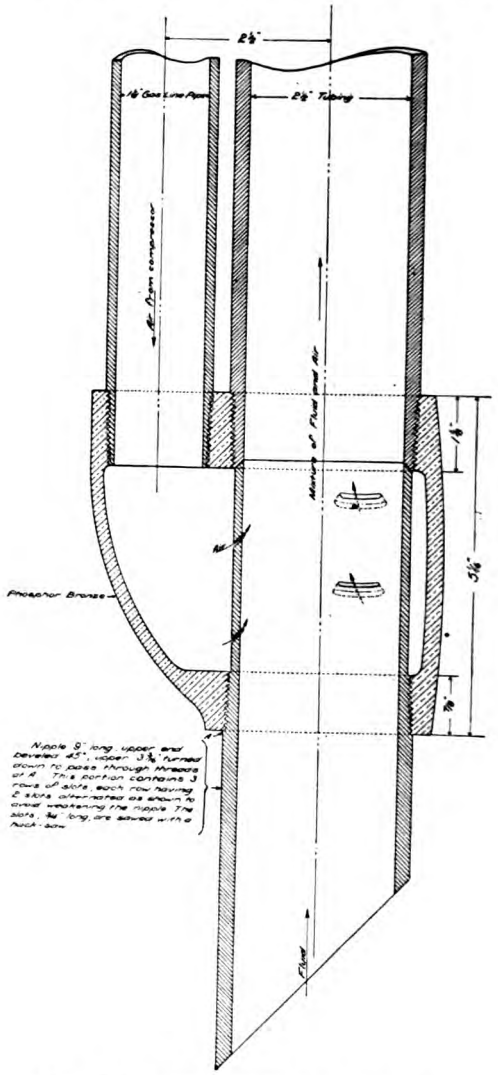

FIG. 2. VERTICAL SECTION OF AIR-LIFT, ASSOCIATED OIL CO.

lower or admission end. It will be seen that the air-lift is operating in the water stratum and the plunger-pump is pumping oil. When discharged the water goes to waste, and the oil to the usual sump for preliminary settling to separate the water and sand. It is

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hardly necessary to point out the advantages of this method as compared to the old one of attempting to handle both oil and water with one pump through one discharge and one suction pipe. The air-lift is not generally satisfactory for pumping heavy oil. The oil is so viscous that the air collects in large globules until it finally accumulates enough pressure to 'blow through' and escapes to the surface carrying little or no oil with it. Its action on water or light oil, however, is ideal, the apparatus being simple, cheap, and requiring no attention and very little repairs.

Well No. 18 S.J. is a typical key well. It is 1200 ft. deep and is operating with air at 182½ lb. pressure at the top and 30% submergence. Figures as to the quantity of air consumed and quantity of water delivered were not available. Edward A. Rix, in a comprehensive discussion of the air-lift published in *The Oil Industry* of June 15, 1910, says: "In a test of air-lift systems in the Kern River field made by the Peerless company, pumping a mixture of water with 20% oil at an average lift of 470 ft., with an average submergence of 40% and an average length of discharge pipe of 800 ft., they found as the average of many tests, air-pressure, 152 lb.; free air per minute, 140 cu. ft.; gallons of fluid per minute, 93; cubic feet of free air per gallon of fluid, 1.5; ratio of free air to fluid pumped, 11. Ninety-three gallons of fluid per minute is equivalent to 3400 bbl. per day. The above pumping was done through 3-in. tubing with 1¼-in. air pipes, and both the straight air systems and also two other so-called patented systems, with the result that no gain was shown by the patented systems; and while in this subject it might be well to say that one well was piped as many as thirteen times, using the straight air system and after each piping better results were shown; in fact, the variation in pipe sizes and ratio of submergence, all within reasonable limits, show a marked variation in economy. The results show conclusively that not only the ratio of submergence, but also the relative amounts of air and water being pumped influence the economy; the gravity of oil also offers its troubles, and there is, over and above all these, the question of the size of the discharge pipe for the fluid, and it is a vital question. Too large a pipe is fatal, because the air slips by; too small a pipe is equally bad because the air escapes and the expansion is checked. The proper size is a matter of experience based on an average velocity of from 6 to 8 ft. per second in the pipe or about 12 to 18 gal. per square inch of area of discharge pipe."

Reducing valves for the regulation of the air-pressure in proportion to the height of lift were tried out, but were unsatisfactory on account of clogging. Regulation is effected by the use of an ordinary throttle valve, the action of the main compressor plant being so uniform that only occasional readjustment is necessary. The oil discharges from each well into a sump, in which the first settling and separation of sand, water, and oil takes place. The oil and water in this district is not so thoroughly emulsified as to prevent a certain amount of natural separation by settling. The oil is decanted from the top of the sump and the water from the bottom, the latter going to large settling sumps near the Kern river by gravity over old creek beds and gullies, the former into a combination heater and receiving tank, from which it is pumped by a steam-actuated plunger-

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pump to the treatment plant for dehydration. An ingenious arrangement consisting of a float connected to the throttle valve of the pump prevents flooding the receiving tank by automatically adjusting the speed of the pump to the height of the oil level in the tank. The exhaust steam from the pump is introduced into the tank through a pipe coil, as the heavy oils of this district are so viscous that heating must be resorted to before the oil can be pumped.

The dehydration plants each consist of four 5000-bbl. steel tanks connected in series, the successive difference in elevation being two feet, so that the oil can overflow from the first tank through the others by gravity. The oil and water emulsion readily separate when subject to heat, so the first two tanks are fitted with pipe coils consisting of a 12-in. header and 2-in. branches connected at the ends with return bends in order that the steam may circulate. The two following tanks are merely receivers, from which the oil is pumped to the station for transportation to the consumer. The dehydration plants are all placed near the compressor plants, so that the exhaust steam from the compressors goes through the pipe-coils and is used for heating the oil before going to the condensers. Thus a double function is performed, and this makes the heating of oil in the treatment tanks not only cost nothing, but increases the condenser cooling surface and diminishes the fuel consumption in the compressor plant. This method of heating maintains a temperature of 150°F. in the heating tanks. Excellent results are obtained by this method of separation. An emulsion containing 50% of water before treatment is reduced to a water content of less than 2 per cent.

The excess water, as well as that from the well-sumps, carries away with it all base sediment, and finds its way to large sumps near the Kern river, where the base sediment is burned before the excess water is allowed to flow in, in order to prevent pollution of the river.

The wells of the Associated Oil Co. make enough natural gas to use for heating and cooking in the dwellings, bunk-houses, etc., and for operating the steam superheaters, but not nearly enough for power purposes. The Peerless Oil Co., operating in the same district, is more fortunate in this respect, as its wells produce enough natural gas to operate a 2600-cu. ft. compressor plant. The natural gas being practically a waste product, fuel is not charged against the cost of operation, which results in a very low cost per horse-power developed. The compressors are the same make and type as those of the Associated company, except that they are coupled direct to gas-engines. One compressor has air cylinders 22 in. and 11 in. diam. by 24-in. stroke, a rated capacity of 1600 cu. ft. of free air per minute to 200-lb. pressure at 150 r.p.m. It is coupled direct to the crankshaft of a Buckeye, 2-cylinder, horizontal, double-acting, tandem, 4-cycle, natural-gas engine, having cylinders 18 in. diam. and 33-in. stroke. The second compressor has cylinders 17½ and 9 in. diam. by 24-in. stroke, and a rated capacity of 1000 cu. ft. of free air per minute to 200-lb. pressure at 150 r.p.m. It is coupled to a Buckeye engine of the same type as the larger compressor, the cylinder dimensions being 18 in. diam., 30-in. stroke, and the speed 150 r.p.m. The manufacturers of the engines based their guarantees for power developed upon natural gas having a calorific value

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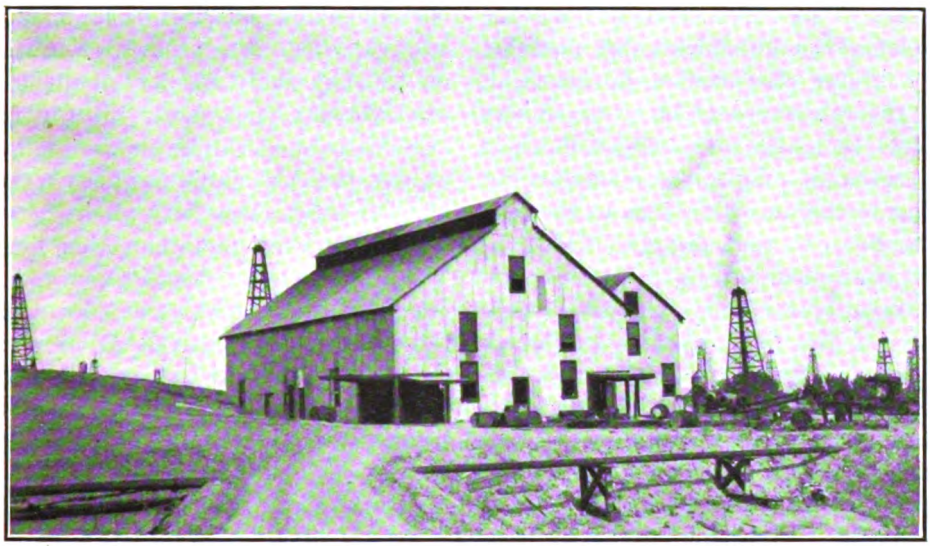
of 600 b.t.u. per cubic foot, the larger engine developing a brake-horse-power of 407 to 447 and the smaller 300 to 320. The maximum power developed gives a safe margin over and above the actual requirements of the compressors, the power developed under ordinary working conditions being 360 and 280 hp. for the larger and smaller engines, respectively, the air-pressure shown on the gauge being 190 pounds.

The figures for cost per horse-power developed are interesting, and are based upon averages of about a year and a half of continuous operation.



PEERLESS OIL CO.'S GAS-ENGINE DRIVEN COMPRESSOR PLANT.

	Per Month.
Interest on investment:	
$50,000 at 8% per year....	$333
Labor:	
1 man at $200; 1 at $135...	335
Sundry materials, lubricants, and repair-parts	96
Total expense	$764

Considered on the basis of continuous operation 30 days per month, 24 hours per day, total horse-power developed taken as 640, the cost of producing 1 hp.-hr. is a trifle under $0.0017. However, 30 days per month continuous operation attributes nothing short of mechanical perfection to the gas-engines, and it is hardly possible that such ideal performance is maintained. On the other hand, it was stated by the management that one continuous run of 160 days was made, which goes to show the remarkable progress that has been made in the development of the internal-combustion engine in recent years. It will also be noted that depreciation and overhead charges are not taken into consideration in calculating the cost per horse-power-hour given above, and also that the cost of maintenance which is included in the two items of labor and material will in all likelihood increase as the plant grows older.

The Associated company follows the plan of shutting down its compressor-plant in sections for one 12-hr. shift every month for examination. The wisdom of this course is apparent at once.

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The plants are arranged in such a way that operations in the field are in no way interfered with, and at the same time small adjustments and repairs are made at once and big break-downs prevented.

The operating methods of the Associated company present a true picture of the recent development of the oil industry. The 'discovery' period with the accompaniment of wild-catting stock-jobbing antics of promoters, always comes first in any development of natural resources. Then came the problems brought about by unstable markets for the product of the field, and the reluctance of large consumers of fuel to make the changes in their apparatus to adopt it for oil-burning owing to the uncertainty as to the permanence of the supply. Development continued, and as doubt was soon succeeded by certainty as to the permanence of the field, smaller producers combined to form larger companies like the Associated, resulting in the substitution of scientific method for guesswork. The geologist, the engineer, and the trained executive now have a place in the oilfield, the result of their work being nowhere more apparent than in the camp of the Associated Oil Co. There are many details that have yet to be worked out. Plans are under way to install cleaning plants at each group of wells in order to do away with the surface transportation of all oil and stop evaporation and seepage losses. It is also proposed to substitute modern water-tube boilers for the return-tubular boilers in all of the central steam-generating plants as rapidly as finances will permit.

While it would appear presumptuous for an outsider to express an opinion on a subject which has doubtless been given careful study by those most interested, the remarkable economies achieved by the high-duty compressor plants, and the fact that they are said to have paid for themselves in less than a year after being placed in commission, would give encouragement for further progress along the same line. Sending steam through pipes over any considerable distance is one of the most inefficient known methods of transmitting power, while transmitting electricity over wires is just the opposite. A modern steam-turbine electric-generating plant, on the basis of 5000-kw. capacity, can produce electricity on the bay shore for less than $0.005 per kilowatt-hour, using oil for fuel. If a central generating plant were built at, say, the Associated company's camp at Oil Center, electricity might be produced for even less than this figure. The fuel cost alone would be only about one-third of the cost in San Francisco. Cooling water is plentiful. All oil pumping and possibly even drilling might then be done by electricity. Power transmitted over many miles of wire is sold at Oil Center for $0.012 per kilowatt-hour. One electric pumping outfit, consisting of the usual bevel-gear and pinion, double eccentric rig, driven by a 30-hp., 1120-r.p.m., type CCL Westinghouse motor, pumps 8 wells and requires one man for attendance. Three of these electric outfits displaced eight 70-hp. boilers and reduced the labor for attendance from 35 to 21 men. It would appear from superficial observation that the building of a central electric-power generating plant would be the next stage in the evolution of large-scale pumping methods. There is no doubt that the Associated Oil Co. will continue the progressive policy that has contributed so largely to the transition of the oil 'game' of yesterday to the oil 'industry' of today.

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Water Resources: Conflict in Use for Municipal, Irrigation, and Power Purposes*

By HERMAN STABLER†

IN THE United States, conflict among the various users of streams is greatest in the relatively arid regions of the West. The importance of the conflict is evidenced by legislative enactment in some states declaring that one or another use shall have preference over others. Perhaps the most extensive declaration of preferred-uses is in the law of Wyoming, which provides preference for domestic and transportation uses, including first, use for drinking purposes for man and beast; second, use for municipal purposes; third, use for steam engines and railways; fourth, use for culinary, laundry, bathing, refrigerating, and for steam and hot-water heating plants. This law provides, further, that irrigation shall be superior and preferred to any use in which turbine or impulse water wheels are employed for power purposes. Such preferential declarations should be considered as being subject to the requirements of public necessity in specific cases, and are, in fact, attempts to put in the statute books an assumed general relation of values of ultimate public necessity. Though they may effect the character of the water right that can be acquired, they should not be understood as specifying the ultimate use of the water of any stream. Water rights applied to private use may be acquired for public use by condemnation under the law of eminent domain, and water rights devoted to public use may be similarly acquired for a public use of greater necessity. By state law and by court decisions many kinds of use under diverse conditions have been held to constitute public use, and the legislative and judicial list of public uses is growing. Development in large units, whether for domestic use, irrigation, or power, under the control of public service and municipal corporations has served in recent years to emphasize the increasing importance of public use of the water of streams. Public necessity, therefore, is the criterion by which the ultimate use of streams may properly be determined. This will vary from stream to stream and from time to time on the same stream. By what rule shall public necessity be measured? The rule of value seems best suited to the case. When one use becomes of sufficient necessity to warrant the cost of development, including just compensation for interference with other uses, it is for the time being the dominant public necessity. But if its dominance is of a temporary character, the natural conditions tending to favor a relatively permanent dominance of one or another use should be carefully considered in any attempt to adjudicate a conflict of uses.

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†Hydraulic engineer, U. S. Geological Survey.

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An indication of the relative values for municipal, irrrigation, and power use of streams in the West, in general, is obtainable from the bulletins of the United States Census Bureau. In the statistics for cities with a population of over 30,000 in the Census bulletin of 1909, the cost of water-supply systems in municipal ownership in six cities in the arid-land states is shown to be from $139 to $329 per acre-foot of annual water-supply, the mean cost being $237 per acre-foot. These costs are only $5 to $10 per inhabitant and it is certain that in case of scarcity of sources of supply they might be very greatly increased, for water is one of the least expensive of the necessities and conveniences of a well-appointed city household. The demand of public necessity, therefore, tempered by the availability of natural water supplies of satisfactory quality fixes the current value of a satisfactorily developed municipal water-supply system in the Rocky Mountain and Pacific Coast states at about $240 per acre-foot of annual capacity.

The Census irrigation statistics of 1909 show that the average cost of irrigation systems is between $5 and $10 per acre-foot of annual water supply. This represents practically the average for ordinary crops. Under present conditions, irrigation systems for watering ordinary farm crops seldom warrant a building cost in excess of $20 per acre-foot of annual water supply; but for specially valuable crops a building cost of $150 per acre-foot of annual water supply is a reasonable maximum. A people urged by prospect of famine could doubtless afford far greater building costs, but in the present period of plentiful food supply and cheap transportation much change is not to be anticipated.

Both municipal and irrigation water-supply systems are largely developed on the mutual plan, not in general being operated so as to produce a direct income; and therefore the cost of systems is perhaps the best index of the value of the developed water supplies for these uses. In the case of hyro-electric power systems, however, par value of outstanding stocks and bonds and capitalized net income are available as additional bases for estimation of value. The following table gives a summary for the eleven Western states, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming, as determined from the Census statistics for 429 commercial, central electric stations in 1907:

DEVELOPED VALUE OF CONTINUOUS THEORETICAL STREAM-POWER

(Assumed as one-half the nominal capacity of primary power machines, per acre-foot per year per foot of effective head).

	Maximum.	Minimum.	Mean.
1. Building cost	$0.194	$0.036	$0.080
2. Par value of outstanding stocks and bonds	0.230	0.036	0.114
3. Net income capitalized at 5%	0.156	0.051	0.094

The maximum and minimum values shown are mean for individual states. Apparently the value of the developed power resources of a stream may be taken for this region at about 10c. per acre-foot of available annual flow for each foot of available effective head. Wide variations from this value are of course to be expected in individual cases. Summarizing the values for municipal, irrigation, and power use, the following interesting comparison results:

CURRENT VALUES PER ACRE-FOOT PER ANNUM OF DEVELOPED STREAM FLOW.

	Actual.	Relative.
For municipal supply	$240	$12.00
For irrigation, specially valuable crops	150	7.50
For irrigation, fair maximum for ordinary crops	20	1.00
For power, per 100 ft. of effective head	10	0.50

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It can not be too strongly emphasized that these values are merely approximations for an extensive area. Increasing transportation facilities and improvements in engineering principles and methods tend to reduce to a minimum the variations in value from place to place, but wide variations between individual localities must necessarily exist and in any particular problem should be carefully taken into account.

It appears from the foregoing summary that water is so much more valuable for municipal than for irrigation or power use that no very serious conflict is likely. Municipal use is so favored that it will rarely fail to triumph. Municipal and power uses, moreover, are not likely to be wholly antagonistic. Both require for their best advantage a fairly uniform flow throughout the year. Pressure for municipal service may require an effective head of generally not to exceed 200 ft., and any additional head may be expected to be available for power purposes. Combined domestic and power schemes, such as find a premier example in the new Los Angeles system, can often be developed to excellent advantage.

Use of a stream primarily for irrigation, concentrating the entire discharge in the irrigation season, practically destroys its value for domestic or power purposes. Not infrequently, however, stream-flow regulation primarily for power and then for irrigation will produce the maximum economic total development, though only a moderate agricultural development.

In the utilization of water resources, each stream should be considered a unit, and, so far as possible, progressive development should be in harmony with the most beneficial utilization of the natural resources of the entire drainage area. As a practical example, consider the Sierra region in California where streams of small or moderate discharge pass over the steep mountain slopes into fertile valleys below. The steep slopes provide specially favorable power sites, but the fertile valleys, with a supply of water for irrigation, are capable of a high grade of agricultural development. The ideal plan of utilization in such a case is to regulate and use the water for power first and then with lower reservoirs regulate for complete irrigation use. Unfortunately,

DISCHARGE OF CATARACT CREEK FOR A YEAR OF MEAN LOW-WATER FLOW.

Month.	Normal	Regulated for power	Regulated for irrigation	Available for irrigation with regulation for power.	Available with normal flow.	
					For irrigation.	For power.
January	1,000	2,200	.....	.....	.....	1,000
February	1,200	1,990	.....	.....	.....	1,000
March	1,400	2,210	.....	.....	.....	1,000
April	1,500	2,140	.....	.....	.....	1,000
May	3,000	2,210	3,900	1,400	2,200	1,000
June	5,500	2,140	6,500	2,200	3,700	1,000
July	3,700	2,210	6,500	2,200	3,700	1,000
August	3,500	2,210	5,200	1,800	3,000	1,000
September	1,700	2,140	3,900	1,400	1,700	1,000
October	1,400	2,210	.....	.....	.....	1,000
November	1,100	2,140	.....	.....	.....	1,000
December	1,000	2,200	.....	.....	.....	1,000
Total	26,000	26,000	26,000	9,000	14,300	12,000
Required storage capacity		6,930	8,600			

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such complete use is seldom feasible. The more common situation is that in which a headwaters reservoir is available but choice must be made between its use for power and for irrigation storage. A typical case of this kind is presented below under the caption Cataract creek. The estimates for irrigation are based on the assumption that approximately 15% of the irrigation water will be required in May and in September, 25% in June and in July, and 20% in August. Any other reasonable assumptions could have been made without materially changing the results.

In estimating values, $20 per acre-foot was taken as the value of water for irrigation and $10 per acre-foot per 100 ft. of available effective head as the value of water for power purposes. Comparison of the values for power and irrigation is given below.

VALUE OF CATARACT CREEK FOR POWER AND IRRIGATION.

	Available head 1000 ft.			Available head 200 ft.		
	Irrigation.	Power.	Total.	Irrigation.	Power.	Total.
Normal flow	$286,000	$1,200,000	$1,486,000	$286,000	$240,000	$526,000
Flow regulated for irrigation	520,000	.....	520,000	520,000	.....	520,000
Flow regulated for power	180,000	2,600,000	2,780,000	180,000	520,000	700,000

With 1000 ft. available head, a fall not uncommon in the region considered, power value far exceeds irrigation value. Regulation for irrigation, thereby practically destroying all power value, would reduce by 65% the total value for power and irrigation. With only 200 ft. available head the irrigation and power values are more nearly equal. Even in this case, however, the combined power and irrigation value of the normal flow exceeds that of the flow regulated for irrigation; and with the stream regulated for power, though irrigation development would be but little more than a third of the maximum, the combined value of irrigation and power is such as to indicate the most beneficial utilization of the natural resource.

Take another practical case considered under the name of Hill river. In this case, the average annual run-off is 1,222,000 acre-feet. An ideal reservoir site renders feasible the utilization of the entire average annual discharge either for power or for irrigation. The value of the streams for irrigation, in view of probable crops and secondary use of seepage water, may perhaps be placed at $50 per acre-foot of annual supply. For power, the conditions as to available market for fuel supply are such that a value of $0.07 per acre-foot per annum per foot of available head, corresponding to a building cost of about $115 per horse-power of 10-hour power for stream development and generating plant and appurtenances, may properly be used. The reservoir site may be developed at reasonable cost so as to provide 120 ft. head for power purposes in addition to the necessary storage for power or irrigation. At a cost of 20 or 25% less, the necessary storage capacity could be secured without providing the additional head for power. Within the first five miles below the reservoir site, an effective head for power of 200 ft. is available from fall in the river. All irrigation development would be below the power sites. Three cases naturally arise:

1. Reservoir regulation only for power. In this case a large amount of water will be available for irrigation also.

2. Reservoir regulation only for irrigation. In this case no power develop-

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ment would be feasible except during the irrigation season.

3. Reservoir regulation primarily for irrigation with partial use for power. Under this case two conditions will be considered: (a) Use of normal minimum flow for power, and (b) use for power of flow such that the maximum total value of the resources will be realized.

The extent and value of the power and irrigation possibilities of Hill river, considered under the foregoing cases, may be summarized as follows:

EXTENT AND VALUE OF POWER AND IRRIGATING POSSIBILITIES OF HILL RIVER.

	For irrigation.		For power.			
	Available supply, in acre feet...	Value	Available supply, in acre feet...	Available head, in feet.....	Value	Total value for power and irrigation .....
Case 1	574,000	$28,700,000	1,222,000	320	$27,400,000	$56,100,000
Case 2	1,222,000	61,100,000	.....	200	.....	61,100,000
Case 3a	1,122,000	56,100,000	240,000	320	5,400,000	61,500,000
Case 3b	815,000	40,800,000	978,000	320	21,900,000	62,700,000

It is evident from the foregoing summary, assuming the correctness of the statement of conditions, that irrigation is the most valuable use for this stream. Use for irrigation to the exclusion of power produces a somewhat smaller total value than combined power and irrigation use over a wide range of relative quantities. The maximum increase in value with combined use far exceeds the increased cost of reservoir to produce additional head for power purposes. Even on streams for which irrigation is clearly the dominant feature of use, therefore, power possibilities should be carefully considered and the importance of combined use for power and irrigation valuated.

Granting the correctness of the valuation of irrigation and power possibilities on the streams cited, should irrigation, as a 'higher' or 'preferred' use, prevail and power for the needs of the region be developed from coal, oil, or gas? Irrigation is admittedly an industry of primary importance in the arid region. It may with reason be considered as the basis from which all other permanent development may start. In general, the water supply fully regulated by storage is insufficient to give agricultural value to all irrigable lands. Permanent alienation of water that could be used for irrigation from the land should therefore be permitted only when some great public benefit, either direct or indirect, is to be derived. On the other hand, running streams are the only permanent source of energy now known that can be utilized on a large scale to furnish power for mining, milling, manufacturing, and transportation, and artificial heat and light for all purposes. Settlement and progress in many regions and maintenance of prosperity in all regions depends very largely on the amount of energy that can be developed and utilized. It is estimated that power development in the United States will exceed the maximum possibilities of our streams without storage in a little more than a hundred years and the maximum possibilities of streams with storage in about two hundred years. With the gradual exhaustion of coal, oil, and gas re-

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sources the necessity for maximum water-power development will become increasingly important and it is by no means unlikely that the necessity for water-power development will increase more rapidly than the necessity for increased food supply from irrigated areas.

Irrigation is naturally first in the field. Moreover, water power transformed into its various energy-forms is supplied by a presumably 'powerful corporation', while irrigation development is essentially made by the farmer as an individual or in groups. Irrigator and power consumer are inclined to join forces in making difficult the work of the power producer who, it must be confessed, too often grows wealthy from unreasonable profits extracted by reason of the extent and monopolistic character of his operations. Control of power operations, however, and not destruction of power resources in the interests of minor irrigation development, appears to be the solution of the rather complicated problem. It is worthy of note that although the value of water for irrigation for ordinary crops is placed at not more than $20 per acre-foot, once a water right becomes vested and agricultural industry dependent thereon reaches a high state of development, the damage resulting from loss of the water may amount to three, four, or five times as much. An industry once developed, together with its network of dependent operations, the difficulty and cost of changing the use of the water supply is a maximum and may be so great as to render the change impossible. A relatively inferior use may, when once established, prevent for all time the most beneficial utilization of a stream. Incipient conflict of possible uses may be resolved into a wasteful monopoly of interests or a harmonious and economical compromise highly beneficial to the community at large. It seems proper, therefore, that local and national governmental agencies, in their respective spheres and in so far as they have the power, should pursue a far-sighted policy of constructive regulation and control over water resources, permitting and encouraging that form of development and only that which is in harmony with what appears to be the ultimate utilization of this great essential to modern life.

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Geology of Midway-Sunset Oilfield of California

By R. P. McLAUGHLIN*

THE largest well in one of the greatest oilfields of the world, namely the Lakeview in the Midway-Sunset field of California, is more or less of a freak and many explanations for its occurrence and behavior have been attempted. Hence, an explanation based upon a theory which seems to be proved by all the development in the field may be of interest, especially as it bears on future development and is not merely a post mortem. The well deserves the name of a freak from the fact of its great production. A glance at the map showing its position indicates that it has many close neighbors. Within a radius of a half mile there are about forty other wells. Most of these have reached as great a depth, but it is probable that no single well within the area has produced one-tenth as much oil in the same or a longer time. Doubtless the entire forty wells have not a total production comparable to that of the Lakeview.

The Lakeview well 'came in' or began to produce in the spring of 1910 at the rate of about 50,000 bbl. of oil of about 19°B. per day and continued for months at only a slightly decreased rate of flow. It was destructive in its violence, being a veritable geyser and very expensive to control. The rig was gradually destroyed by the force of flowing oil and its geyser-like appearance stopped only after a dam was built around it, forming a pool of oil about 100 ft. in diameter and 20 or 30 ft. deep. This body of comparatively still oil acted as a baffle to the upward stream, which still arose above the surface about 10 ft. The appearance of the reservoir was like the surging waters in a rock cave along the sea-shore, during a period of large breakers. The well finally ceased flowing, and when the reservoir was emptied of oil it was found to be a cone-shaped crater, fully 30 ft. below the original land surface. Production has not yet recommenced. Some most extravagant descriptions of this well's behavior have been printed and a report became current that the men actually at work continued after the officials had become discouraged and ordered that operations cease. General knowledge of the operating conditions and statements by officials flatly contradict this.

My examination of the territory nearly a year before the well struck oil, indicated that the land should be productive, but of course no stretch of the imagination could have rivaled what actually developed. At that time the nearest developments were about a half-mile to the south and west, and estimates of the probable depth to oil at the Lakeview, based on geologic observations, were within 100 ft. of the true

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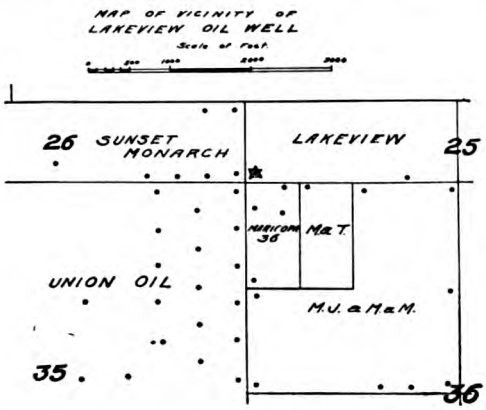
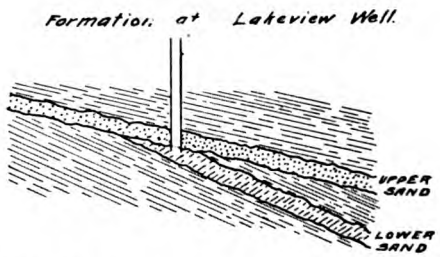
depth. This fact alone refutes rumor that operations had been ordered stopped on account of discouraging



outlook, and at the time added to astonishment at the phenomenal production.

After the well 'came in' a number of explanations of its unusual production were advanced. Among them were the following: (1) a northwest-southeast fault near the well and south of it; (2) an underlying virgin sand extending under most of the already developed field; (3) a large cavity or pocket. The theory of a fault is not supported by surface evidence, nor by a cross-section of the wells due south of the Lakeview. That there is not an underlying sand south of the Lakeview has been proved by some of the wells in section 36, one of which was drilled through all the oil-bearing formations and into the underlying brown shale. A pocket or cavity large enough to contain the oil already produced from the Lakeview would probably have been touched by some of the other wells and, furthermore, a similar occurrence is not indicated by other developments.

The theory that seems most acceptable was first suggested, so far as I am informed, by Robert B. Moran, and has been amplified by myself in study of the greater part of the field by means of the logs of completed wells. It is that there are two separate and distinct strata of oil sand differing in their slope or dip. The lower or older sand was laid down horizontally along with overlying and underlying clay and shale. Afterward the western margin of this series was raised, giving a dip to the east. It was then partly washed, or eroded, away, leaving an upturned edge. On these upturned edges of clay and sand beds another series of sand and clay strata were deposited in a horizontal position. Finally both series were still further inclined into their present positions, dipping to the northeast. The sand beds in the two series probably do not extend indefinitely with a constant thickness but, judging from observed exposures in the neighborhood, are in the form of lenses, being thick near the centre and gradually thinning out toward the edges.



Probably also the sand beds as they dip downward toward the northeast, carry water at lower levels instead of the oil that fills the spaces between sand grains above.

Bearing in mind the probable thinning out and disappearance of some sands and the possibility that they in places lose their identity as oil sands and become water sands farther down the dip, the illustrations (Fig. 1, 2, and 3) show the conditions to be expected. The figures are cross-section drawings as the formations would appear in cut-

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ting across the field in the direction of the dip. Fig. 1, a position in which a well might penetrate both the upper and lower sands, as the upper sand in productive form extends over the upturned edge of the lower sand. Such a condition as this doubtless exists in the northern part of the Midway field, as

Figure 1.

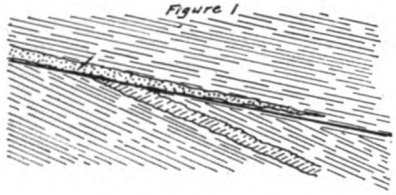


Figure 2.

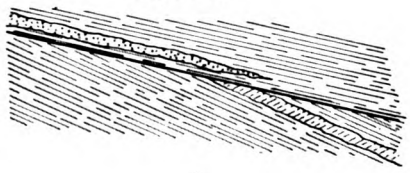
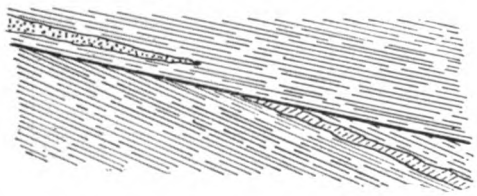


Figure 3.



indicated by the accompanying map of sections 5, 6, and 8, T. 32 S., R. 23 E. Fig. 3 shows the upper sand as either pinching out or containing only water before reaching as far down the dip as the upturned edge of the lower sand. In such a position, a well might be put down and not penetrate either oil sand. This condition, marking a barren area, very likely does occur in some places, as indicated on the map at sections 14, 15, 23, and 24, T. 32 S., R. 23. E., and section 32, T. 32 S., R. 24 E. Fig. 2 shows an intermediate condition where the upper sand becomes unproductive at about a position directly over the edge of the lower sand.

In referring to the accompanying map, it must be borne in mind that the edges of the two sands shown are underground and not exposed to direct observation, but are determined only by results of drilling. As wells are sometimes not properly drilled for various reasons, such, for instance, as to shut off water or to recognize an oil sand when found, the data upon which the map is constructed is not entirely reliable. Furthermore, the territory is not entirely drilled and complete data not yet at hand. However, as practically every well in the field has been studied, the map is believed to be sufficiently accurate to be useful in the future development of the field and to direct attention to the fact that all lands in the field are not of equal value. Appraisal of any piece of land or the outlining of development should be preceded by a thorough investigation in which the above mentioned conditions are kept in mind. The eastern limit of the lower sand is not yet determined.

Returning to consideration of the Lakeview well, attention to which is chiefly valuable as throwing light upon future development in the field, it will be seen by reference to that particular figure that the well probably entered the lower sand near where its upturned edge was close to the upper sand from which the wells to the south had previously been producing. There seems to be a general and marked difference in the oil of the two sands. The oil in the lower sand, sometimes referred to as 'the gusher sand,' on account of other large wells struck since the Lakeview, is usually of higher gravity, 20 to 25°B. and accompanied by more gas than that in the upper sand, which is 15 to 20°B. This is reasonably explained on the basis that the lower sand has remained sealed, preventing loss by seepage or evaporation. As a usual

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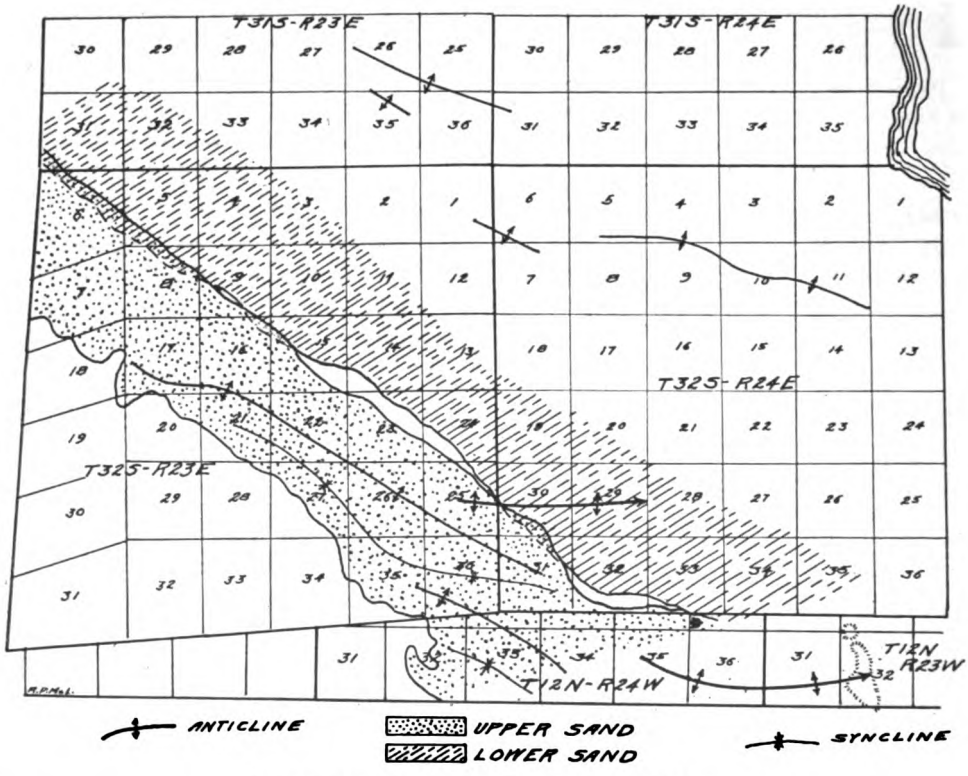
thing through the field, clay predominates largely over sand, and probably at nearly all points the upturned edge of the lower sand is effectually sealed, by clay beds at the base of the upper series, against escape of oil and gas or the entrance of overlying water. Many samples of sand from wells have been compared, but I have never been convinced of any general or marked difference in appearance or size of grains sufficient to permit distinguishing the two formations.



MAP OF NORTHERN SECTION, MIDWAY FIELD.

It has long been recognized that in the oilfields of the San Joaquin valley, the surface of the ground reflects the underground structure. Practically every anticline in these oilfields is indicated by a ridge. In the area under discussion this is particularly true, and developments of the past two years show that more reliance could have been placed on the topographic evidence. As instances, attention is directed to the anticline shown on the map, running eastward from section 25, T. 32 S., R. 23 E., and the one extending eastward into section 32, T. 11 N., R. 23 W. The position of both anticlines has been determined by wells, but they are also indicated by low ridges; evidence formerly accepted with considerable doubt as to its practical value. The second anticline mentioned has been particularly productive. The other anticlines shown on the map can be directly observed on the ground and are here shown as indicated on maps in Bulletin 406, U. S. Geological Survey, as is also the western limit of the upper sand.

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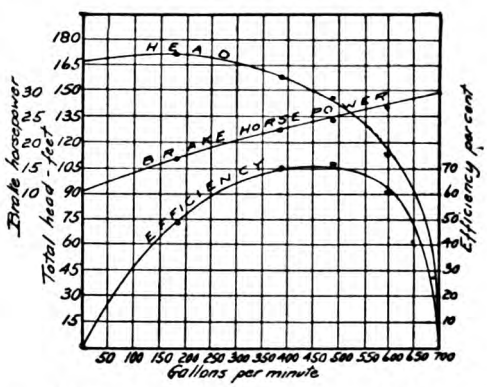
Municipal Water Supply in a Small Town

By C. F. BRAUN

THE town of Kingsbury is one of the many growing small towns in the San Joaquin valley, and has a population of about 1000. In order to keep pace with its progressive neighbors, and to secure its share of California's increasing population, the city fathers planned a system of water works for which the people voted a $26,000 bond issue. In view of the rapid growth of nearly all towns in the vicinity it was considered conservative to provide for a population of 2000, and the system was designed accordingly. Good wells had previously been developed at various points in the town, and as the country is absolutely level, the plant was placed as near the business centre as possible. The supply of water is obtained from two wells situated near opposite ends of the pump-house and about 40 ft. apart, so that each is out of the zone of influence of the other. The wells are about 80 ft. deep and are cased with No. 14 iron well-casing. A combined flow of about 900 gal. per minute is produced, the water being clear, palatable, and only slightly hard. The surface water level is about 8 ft. with respect to the ground and is lowered to 20 ft. when the full quantity of water is being pumped. Particular care was taken that the part of the well casing near the surface should be made tight, so that surface water would be excluded from the well, and possible contamination avoided.

Owing to the small size of the plant, automatic operation was desirable as far as possible, and the electrically driven centrifugal pump was selected as meeting the requirements. The general-service pumping unit consists of an Alberger 4-in., 2-stage, turbine-type, centrifugal pump, direct connected to and mounted on common cast iron base with a General Electric induction motor, operating at a synchronous speed of 1800 r. p. m. The motor is of the squirrel-cage type rated at 30 hp., with an overload capacity of 25% for two hours, and operating on 440-volt, 60-cycle, 3-phase current.



CHARACTERISTIC CURVES, ALBERGER TWO-STAGE TURBINE PUMP, CONSTANT SPEED 1720 R.P.M.

The normal rating of the unit is a delivery of 450 gal. per minute against a total head of 150 ft., with an over-all efficiency from electric line to water, of 60%. Under test, an actual over-all efficiency of 62% was obtained, which is

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a result exceedingly gratifying with so small a unit. The pumps may discharge in the tank or mains as desired. By reference to the curves, it will be seen that the characteristics of the pump are such that at no point over the entire range of discharge, even with closed discharge valve, can the pressure developed by the pump exceed the normal by more than 12%. The pump is absolutely automatic in this action, and a dangerous pressure cannot possibly be developed on the mains or pump casing.

It will be observed that the head curve is unusually flat. Expressed in words, variations in capacity above and below normal do not produce great variations in the pressure. This characteristic is very desirable in water works' service, for if water is pumped into the mains the quantity required is continually varying, while if into a tank the head varies. By examining the power curve, it will be seen that under no conditions of load can the power required be greater than 20% above normal, the motor and other electrical equipment thus being protected from overloads beyond their capacity. This feature is important, as with other types of apparatus the rupture of a pipe main and consequent sudden reduction of head on the pumping unit often causes overloading the motor to such extent as to destroy it. This unit is thus made practically fool-proof without the aid of relief valves, by-passes, or other protecting or regulating devices.

It will be observed that such characteristics as described above are also adapted to fire-fighting purposes. One good fire stream can be delivered automatically at 74 lb. pressure, two good streams at 62 lb. pressure, or three fair streams at 32 lb. pressure.

The attention required and the cost of upkeep for such a unit are practically nil. The only parts requiring lubrication are the two bearings on the pump and two on the motor. These are ring-oiling, and are constructed with renewable bronze bushings so that in case of wear a replacement is a matter of only a few minutes. The pump is provided with a marine-type thrust-bearing to take care of any slight, unbalanced thrust that might develop,

PUMPING STATION.

due to wear in the pump, and slight inaccuracies in manufacture. The thrust-bearing is water-cooled, which prevents any possibility of heating. The water passages of the pump, including impeller and diffusion vanes, are of bronze, carefully machined and polished, which insures long life and sustained efficiency.

While the efficiency of such an outfit may not be quite as high as that of a

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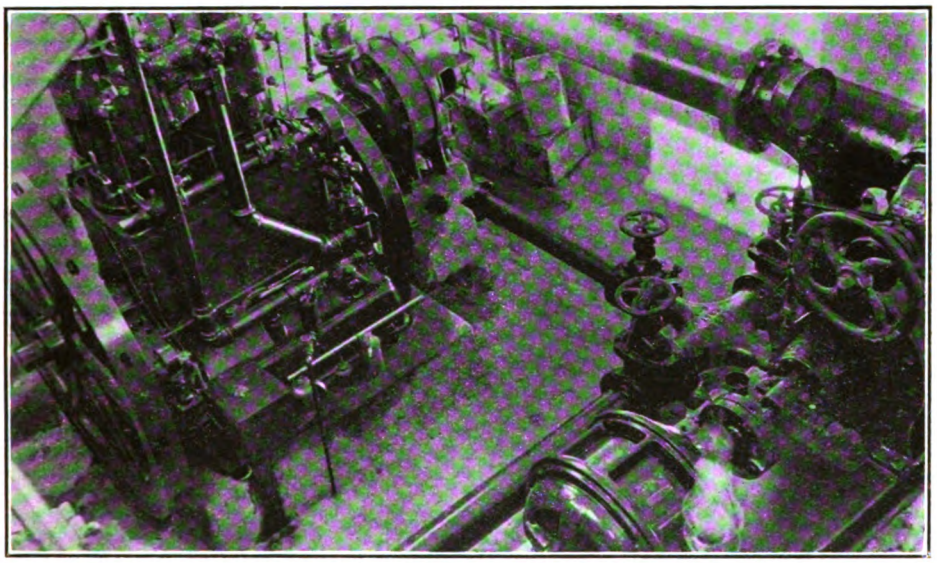
plunger pumping-unit under test, the efficiency of the centrifugal pump will be maintained in actual service, whereas leaky valves, poorly packed stuffing boxes, and general wear will soon reduce the initial efficiency of the triplex to a much lower figure. Electrical energy to operate the motor is purchased from the public service corporation whose lines serve the town. Transformers to step down the primary voltage from 4000 to 220 are placed outside the pump house. To insure continuous service, according to the requirements of the fire underwriters, when two sources of power are used, and to be independent of electric power corporations, an auxiliary gasoline-engine pumping-unit was provided. The pump-end of this unit is an exact duplicate, both mechanically and hydraulically, of the motor-driven pump, so that parts are interchangeable. The pump is mounted on a common cast iron base, and gear-driven by a 30 hp., three-cylinder, vertical, gasoline engine operating at 350 r. p. m. A gasoline supply-tank is placed underground outside the building.

The pumping machinery is situated in a concrete waterproof pit 12 ft. long, 14 ft. wide, and 8 ft. deep. This places the pumps at the water level so that the suction lift is reduced to a minimum, which is a desirable condition for the best operation of centrifugal pumps. A 6-in. suction pipe runs from the bottom of the pit horizontally to each well and extends 30 ft. down, terminating with a foot valve. Each suction pipe is provided with gate valve inside of pump pit so that each well may be operated independently. A 3-ft. manhole and pit over each well provides access to the suction pipes and foot valves for cleaning or repairs. A house 40 by 40 ft. covers the pump pit and also contains a meeting room for the city officers and a room for hose wagon and small fire-fighting apparatus, a very convenient and economical arrangement. The house is constructed of metal lath and concrete, so that it is



INTERIOR OF PUMPING STATION.

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fireproof and at the same time inexpensive. A 60,000-gal. steel tank on a 100-ft. tower provides an adequate reserve supply for domestic or fire service. Four converging legs with wind bracing and struts, resting upon concrete blocks form the tower. These support the tank, which is 19 ft. diameter, 22 ft. deep, and with hemispherical bottom 10½ ft. radius. A conical roof gives the structure a finished appearance, and excludes birds and dirt.

A float in the tank makes an electrical connection when the water level is reduced to 4 ft. below normal, and the motor-driven pumping-unit is automatically started by a solenoid-resistance-type starter. When the water level again reaches normal, the float breaks the contact and the pumping is stopped. A regular operator can therefore be dispensed with. The city employs a man who makes service connections, collects money, and attends to all general water department business, and merely looks over the pumping machinery occasionally to see that the oil reservoirs are full.

The population to be served at present did not warrant a very elaborate distributing system. Care was taken in laying out the system, however, so that lines would be sufficiently large for fire-fighting purposes, and that extensions could readily be made. The money available for this work limited the selection of pipe to steel casing with lead joints. This was carefully dipped in asphalt so that corrosion would be retarded, and reasonable life obtained. Two thousand feet of 8-in., 18,000 ft. of 4-in., and 11,000 ft. of 2-in. lines were laid. The cost of the entire plant was about $24,000. Olmsted & Gillelen of Los Angeles were engineers, and C. F. Braun & Co. of San Francisco were constructors of the entire work.

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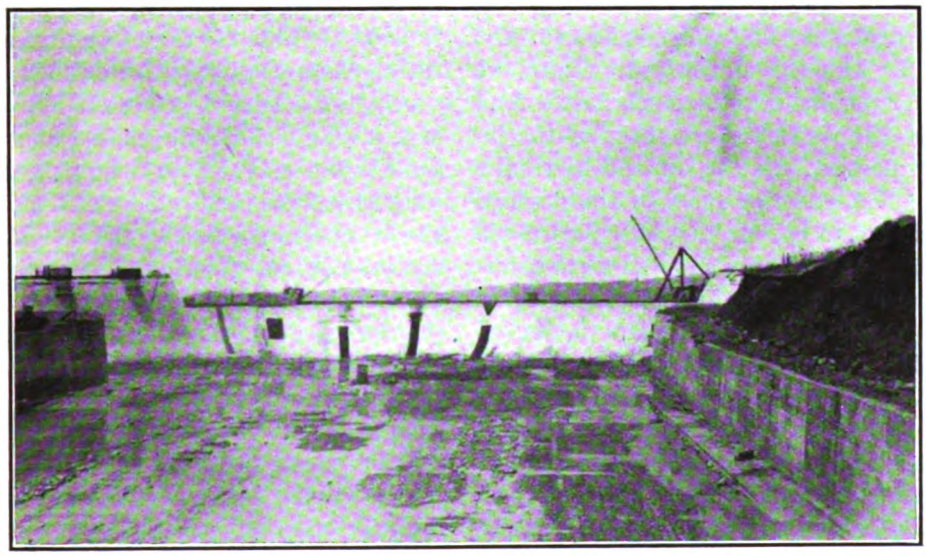
The Suction Dredge at Panama

By J. F. SPRINGER

THE route of the Panama canal follows the valley of the Chagres river for a considerable distance. The method adopted for the control of this torrential stream requires the creation of a large lake whose level will be the summit-level of the canal. This lake will have an area of about 164 square miles. A freshet which formerly would have occasioned a 20 or 30-ft. rise in the Chagres river will, with this large body of water situated within the watershed, result in only a moderate change of level. The great Gatun dam at the northern end of this lake will have the duty of restraining the water. The dam is to be constructed of earth. Spillway hill divides the dam into two parts, one extending east to the vicinity of Gatun locks, and the other to a natural barrier on the west. The elevation of the water impounded by this dam will be normally about 85 ft. above sea-level. The plans provide, however, for a dam whose crest is 115 ft. above the sea. The control of the level is to be secured through the spillway and its accessory apparatus. The dam itself is to have a wide base, over one-third of a mile. Along the north and south edges will be substantial ridges of rock which form the rock-toes of the dam. The space between the inner base-lines of the toes is about 1100 ft. wide. The south or upstream toe will be a substantial pile of rock itself, with its flat-



SPILLWAY, GATUN DAM.

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tened summit at the 60-ft. level. The northern or downstream toe will be a much smaller pile of rock. The space between the two toes is being filled with earth. The earthen fill is to be carried up to a much higher level, however; in fact, it will form the main body of the dam. On its flattened summit a thick layer of rock is to be placed. This layer is to be connected with the rock toe on the north by a 10-ft. protective covering of rock. The earthen fill between the toes is not to be at all uniform. The great central portion is to be what is known as a 'hydraulic' fill. Its base will be perhaps 800 ft. wide. The faces will slope upward to the edges of the summit-layer of rock. On the upstream side this slope is to be 2 to 1. On the downstream face the lower portion is to be much flatter than this. These slopes are those of the inner portion, that is, of the hydraulic fill. The exterior faces of the finished dam are to be, for the most part, even flatter. The slopes adopted were determined principally by the character of the earthy material available in the vicinity. This material is clay, and is consequently very slippery. With a proper width of base, this material is regarded as being just as stable as less slippery earth with a steeper slope.

The method of building the interior mass, consisting of the clayey material, is to mingle the excavated earth with water, and then transport the mixture to the site. The material in suspension settles, forming a solid mass. The excavation and transportation is accomplished by means of a pipe-line dredge, the transportation being assisted, if need be, by relay pumps. At the point of delivery, a lake or pond will form. The mass of the embankment grows by aqueous deposition at the bottom of the lake. The presence of the body of water on the summit of the embankment is regarded as an advantage, for the reason that it continually tests the dam as it forms. It finds weak and open places, and has a tendency to strengthen and close them. The method of dredging and pumping being used on the Isthmus is applicable to other materials as well. Sandy and gravely materials may be handled in precisely the same way. The clayey materials in the neighborhood, which are suitable for use in the dam, and are adapted to the dredging-pumping method, have been estimated to amount to 30,000,000 cu. yd. or more, all of which contain some sand. Loss would be inevitable, perhaps as much as 40%. It is barely possible that, in addition to the above sources, sand from Limon bay nearby may have to be used. In this case it may be advantageous to mix the sand with clay. Two channels running across the eastern side of the dam-site were cleaned out by the use of the suction dredge. Work was begun with one 20-in. pipe-line suction dredge in the spring of 1908. One of the channels was a section of the French canal; the other was the old bed of the Chagres river. The only filling by hydraulic means until April 1, 1909, was in the French canal. By July 1, three dredges were at work filling up the river channel. At first no relay pumps were necessary. A great deal of rock had been placed in the north and south toes. The work of adding rock went on simultaneously with that of filling up the intermediate embankment. The pipe-lines, however, had to cross the piles of rock. By holding the pipe-lines below the finished grade it was possible to avoid interfering with the building up of the toes. This arrangement enabled the lower portion of the hydraulic fill to be carried on with a minimum

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lift. It was necessary, of course, to rearrange matters as the construction went on. During the operation of filling up the French canal, the surplus water was pumped away. For the rest of the work, gravity drainage is said to have been satisfactory, according to report of 1909. The pipes extended back from the outfalls into open ditches by a moderate upgrade. At the inner end, however, they rose vertically to a point near the surface of the lake on top of the fill. The vertical portions were added to as the work advanced.

Another 20-in. suction dredge was built, which was to be used in connection with the Gatun fill. This dredge, while in the care of the tug, was, unfortunately, lost at sea before reaching its destination. The builders, the Ellicott Machine Corporation, of Baltimore, immediately began work on a duplicate dredge. In just about five months, this dredge set out in tow of a tug for the Isthmus. In about three weeks it arrived safely, and was soon put to work at the north Gatun dam, between the spillway and the locks. It is known as dredge No. 86. When this new piece of apparatus had been brought to its position by way of the French canal, a total of four suction dredges was assembled upon one job, the construction of the great hydraulic fill. The new dredge, No. 86, was an important addition to the equipment. It was able to excavate to a depth of 2 ft. and discharge material 7000 ft. through a 20-in. pipe. It is of steel throughout, has a length of 150 ft., a breadth of 40 ft., and a depth of 11 ft. It draws about 7½ ft. of water. The framing is transverse. There are two longitudinal and four transverse bulkheads. These give strength and stiffness. There is one main pump operated by side suction. Four Scotch marine boilers are employed, using crude oil for fuel. Coal may be used instead, however. The oil burned during the first operations of this dredge was supplied from a tank on a hill near Gatun locks. The oil ran by gravity from this tank through a 5-in. main, laid along the northern rock toe of the dam to the brink of the lake or pond where the dredge was working.

A 3-in. lead paralleling the discharge pipe connected the main and the dredge. The discharge pipe itself was carried on pontoons. The 3-in. lead passed from pontoon to pontoon, using flexible joints. The new dredge at once began to show its capacity for work. During the first 34 days it was not operated at capacity in order that all parts might adjust themselves under working conditions. Only three of the four boilers were put into service. In spite of its operation at less than normal capacity, 151,660 cu. yd. of material was pumped into the hydraulic fill in 34 days, an average of 4461 cu. yd. per day. The material was sand from a bank which had been formed in the old channel of the Chagres river. In the month of June 1910, the three 20-in. suction dredges No. 82, 83, and 85, pumped into the fill 370,955 cu. yd. No. 86 began work June 28. During July, with No. 86 working at less than capacity, as has been explained, the four pumped 462,092 cubic yards.

The eastern section of the hydraulic fill had reached, at the end of August 1910, an average level of 57.3 ft. above the sea. It was deemed advisable to suspend work upon this portion in order to permit drying out and consolidation. At the end of September, the level had dropped to 56.0 ft. The suspension was made, moreover, for the purpose of bringing up the level of the western section, as well as for the reasons already given. At the end of

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September that section had reached a height of only 27.3 ft. above the sea-level. At this height it was scarcely fully prepared to withstand, with security, the floods that might be expected in November. The construction of the hydraulic fill of Gatun dam is perhaps the largest undertaking of its kind in engineering history. Up to the end of the fiscal year on June 30, 1911, a total of 7,909,615 cu. yd. of material had been put in place. The cost of this work, including administrative and general expenses, was $2,095,449.24, or an average of $0.2649 per cubic yard. Precisely what this expense includes will be understood better from the items for June 1911, when the total cost was $0.2735 per cubic yard; not far from the average cost.

The following is a tabulated statement of cost of hydraulic fill of Gatun dam for 1911:

Clearing site	$0.0006
Clearing for dredge	0.0034
Dredging	0.0678
Relay pumps	0.0077
Pipe-lines	0.0449
Wood flumes	0.0428
Power	0.0028
Small boats	0.0016
Maintenance of equipment	0.0325
Plant arbitrary	0.0500
Division expense	0.0044
Administrative and general expense	0.0150
Total	$0.2735

It will be noticed that dredging proper cost only about 25% of the total. The figures given above, which are official, are based on a quantity of 432,008 cu. yd. Expenditures of all kinds are included, except those for sanitation, hospitals, and civil government. On June 30, 1911, the hydraulic fill of Gatun dam represented nearly all of such work which had been carried out on the Isthmus. At Miraflores, on the Pacific side, a small amount had been done. Also, in the construction of the Gatun-Mindi levee, a small total of 20,398 cu. yd. of material had been placed hydraulically at an expense of $0.1708 per cubic yard.

The pipe-line dredges are by no means the only suction machines in use at Panama. Important excavation work is being performed by the suction method. Sections of the canal proper are being dug by the two sea-going suction dredges, *Caribbean* and *Culebra*. The central portion of the Panama canal will have a water-level at about 85 ft. above the sea. As the depth is to be 45 ft., this means that excavation throughout this section goes to the 40-ft. level. This portion of the canal extends from Gatun locks on the north to Pedro Miguel on the south. Almost the whole of the total excavation yardage here is dry excavation. The steam-shovel is the chief mechanical appliance employed in the execution of this work. Neglecting the short section of the canal between Pedro Miguel and Miraflores, all the rest of the waterway will be at the sea-level. That is to say, the canal will extend on the north from the Gatun locks not only to the shore line of the Isthmus, but out through Limon bay to deep water in the Caribbean sea; and on the south from Miraflores locks out to deep water in the Pacific ocean. There are thus two important terminal stretches where the banks of the canal lie beneath salt water. However, the tidal changes on the southern or Pacific end are so large that the banks, or portions of them, will perhaps be occasionally in sight. Those who have given the matter no thought may be somewhat surprised to learn of the invisible portions of the canal. There are such portions, and their construction constitutes a large item of the total excavation. At the close of the fiscal year on June 30, 1911, the dredging excavation on the Atlantic end had amounted

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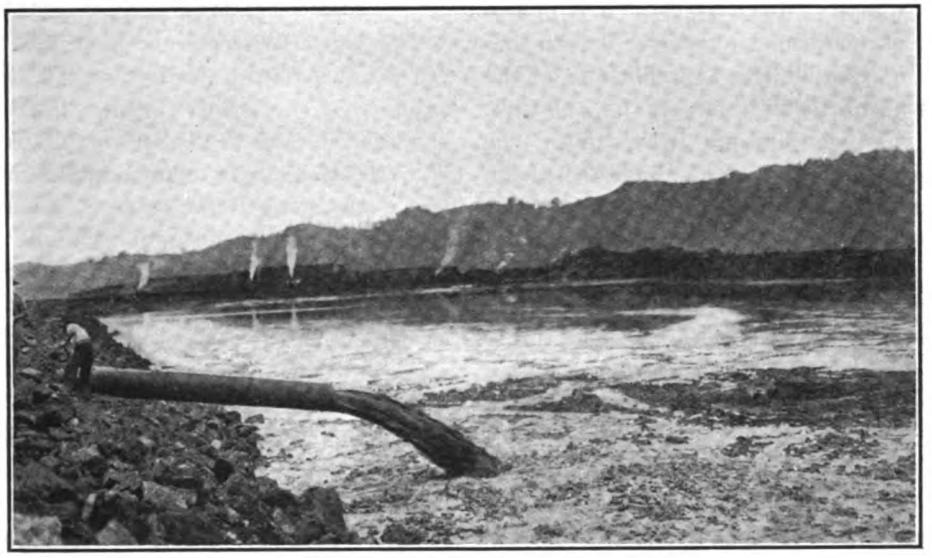
to a total of 23,972,128 cu. yd. At the same moment the total for the Pacific end amounted to 28,586,972 cu. yd. The whole of this 52,559,100 cu. yd. came out of the canal proper. And the great bulk of it was done by the suction method. The *Caribbean* operates on the Atlantic end. Of the total dredging excavation accomplished from April to June 1911, inclusive, the last quarter of the fiscal year, this single dredge excavated 1,021,600 cu. yd. of the total of 1,346,938 cu. yd. of material taken out from the Atlantic end of the canal proper by dredges. Similarly, on the Pacific end, a single sea-going suction dredge excavated during the same period 621,670 cu. yd., against 836,379 cu. yd. taken out by the rest of the Pacific dredging fleet operating on the canal channel.



HYDRAULIC CONSTRUCTION, GATUN DAM.

There is, of course, work for which the suction dredge, whether pipe-line or sea-going, is unfitted. The suction dredge cannot deal with a ledge of hard rock; nor can it deal with boulders too large to enter the openings. But it can deal with pretty nearly everything else. If the objects can pass in through the apertures, their specific gravity will not make them impossible to handle by this method. The *Culebra*, a couple of years ago, sucked 60 ft. of iron chain from the bottom of the bay in which it was then working at the Isthmus, passing it through the pumps successfully. The *Caribbean* drew a cannon ball from Limon bay. The modern suction dredge is accustomed to deal with loose rock. It is by no means confined, in its operation, to sand and gravel. With dredges like the *Caribbean* and *Culebra*, the spoil taken up from the bottom is passed through the pumps into the bins. Here the solid matter settles, forming about 60% of the whole. Clay, gravel, and sand are sucked in. No harm is said to result from sucking in pieces of rock almost as large as one's head, and passing them through the pumps. Similar remarks could be made with reference to such dredges as pipe-line suc-

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tion dredge No. 86, to which attention has already been directed. These ships, and ships they are, operate 24 hours per day. They are able to deal with material 50 ft. below the surface. When operating on the canal channel, they ordinarily need no auxiliary boats. They run along their course, dredging a furrow alongside of a previous one, in a very short time. Then they go under their own power to the dumping point, where the contents of their bins are quickly discharged. This operation is performed by power-driven machinery, which drops the bottoms of the bins and afterward effects their closure. All this occupies but little time. The dredge then returns to the work of excavating and goes through the same operation as before. It might be thought difficult to excavate by running furrows which are always out of sight. However, it is not absolutely necessary that successive furrows shall precisely adjoin each other. Some latitude is allowable, for the reason that the subsequent movement of the water tends to remove irregularities.

An examination of the costs of dredging by the suction method will show at what reasonable figures it can be done. A suggestion of their economical mode of operation has already been made when dealing with the work on the hydraulic fill. The reasonableness of the pipe-line dredging expense is confirmed by figures referring to work done by the sea-going suction dredge. Taking June 1911 as a typical month, the following was the cost for the *Caribbean*, per cubic yard:

Operation	$0.0310
Repairs	0.0138
Small boats	0.0031
Repairs, miscellaneous equipment	0.0012
Plant arbitrary	0.0610
Division expense	0.0185
Administration and general expense	0.0185
Total	$0.1471

The last five items are averages for the whole Atlantic dredging fleet. The expense of suction dredging, shown by the figures to be $0.1471 per cubic yard, is quite small. In comparing it with the work being done by pipe-line suction dredges at Gatun, it must be remembered that the matter of disposal of the spoil is very different in the two cases. With the sea-going dredge, it is a simple matter, ordinarily. It makes a run to the dumping spot and effects a wholesale discharge. The dredges working on the fill of the Gatun dam not only have to excavate, but they must dispose of the spoil through a pipe-line and against resistance. In fact, dredges performing such work as that of the Ellicott dredge No. 86, accomplish two operations simultaneously, excavation and construction economically and efficiently.

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The Engineering Digest

Work and Publications of the United States Government Relating to Hydro-Electric Development*

By JOHN C. HOYT†

JAMES J. HILL, the famous railway builder, once said, in addressing a group of government engineers: "Next to the Deity, the civil engineer comes nearer to being a creator than do men of any other profession. He wants only a cheerful banker to advance the wherewithal for expenses and he will attack any problem in nature and master every difficulty of construction."

In this striking statement, Mr. Hill probably assumes that if the success of the undertaking is to be assured, the engineer would have at command, in addition to the necessary financial resources, a working knowledge of the essential factors entering into the problem which he attacks. Without such a knowledge, the economical completion and successful operation of a project is doubtful, for many a failure can be traced directly to errors due to lack of knowledge of the prime conditions on which the success of the project depended.

Every engineer who is required to devise a project of any sort must first procure and consider all available data that may in any way be of value in his proposed work. In general, the limit of time and funds available for the investigations required for a conclusive engineering report prohibits the engineer from collecting original basic data. He must accept data gathered by others, and on the amount and character of data obtainable and his ability to bring the facts together and analyze them, the value of his report must depend. Definite knowledge of the sources of reliable data is, therefore, essential. In this connection it may be noted that the work of the investigating engineer must precede and serve as a foundation for all designs and construction. His place is, therefore, as important and should command as much respect as that of the designing and constructing engineer.

In the department of the National Government there are many technical and scientific bureaus engaged chiefly in studying the resources of the country and indicating the manner in which these resources may best be utilized and developed, and some of these bureaus also carry on construction and development work for the benefit of the people. Governmental investigations are, of course, conducted impartially, and all sides of the subject under consideration are studied and recorded, information unfavorable to a project being quite as essential and valuable as that which is favorable. Most governmental investigations can also be carried on more thoroughly and systematically than those of the private investigator, who must satisfy a demand for immediate financial return. The scientific work of the Government employs a large corps of men who have devoted years to special lines of study with such success that the methods and results of governmental investigations are now accepted as standard not only in this country, but in many foreign countries.

In reports on hydro-electric projects, three things must be considered and appraised at their proper value: (1) the quantity of power available; (2) the cost of its development and distribution; (3) the available market and the probable returns. Governmental data of value in connection with such reports may be grouped under six sub-

*Read before the National Electric Light Association, at Seattle, June 10, 1912.

†Engineer in charge of surface water investigations, United States Geological Survey.

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jects. The principal bureaus engaged in investigating them are as follows:

Geological Survey.—Prior to 1879 no systematic studies of our natural resources had been made by the Federal Government. In that year the Geological Survey was organized under an act which specified its chief function as "the classification of the public lands and the examination of the geological structure, mineral resources, and products of the national domain." Working under this broad charter, the Survey collected and combined the results of all previous investigators and adopted a program which has been extended to cover the whole country. In carrying on the work as defined in the organic act, it has been necessary to study many allied subjects, so that data relative to practically all of our natural resources and the conditions affecting them are now available in the Survey. The work may be classified under the headings of geologic surveys and investigations, topographic mapping, mineral statistics, water resources and investigations, classification of the public lands, which utilizes the work of the other branches.

Keeping in close touch with other organizations, both governmental and private, which are studying the natural resources of the country, the Survey acts to a certain extent as a clearing house for all such information, and if its own records lack the desired data, it can frequently suggest the source from which they may be obtained.

Reclamation Service.—This Service, which is primarily a construction bureau, was organized for the specific purpose of reclaiming arid public lands. Its work was made possible by the earlier investigations of the water resources branch of the Geological Survey, and its projects have generally been based on water-supply data collected by that bureau. Its own investigations are necessarily restricted to those factors which relate to particular projects under investigation or construction. Nevertheless, the Service has collected a large amount of valuable data covering all phases of investigation, construction, and operation of irrigation development, including power as a necessary part or as a by-product thereof. These valuable data should not be overlooked by those who are interested in projects in the arid land states. The maps and detailed surveys made by the Reclamation Service cover large areas, and its designs of systems and structures exhibit the best practice in many types of engineering construction.

Weather Bureau.—From the viewpoint of the engineer, the most valuable data gathered by the Weather Bureau are the precipitation records that have been collected at stations well distributed throughout the country. Many of these records cover long periods, and, in general, they are sufficiently complete to indicate average and extreme conditions. Not only is the summary of precipitation records, recently compiled and published by the Weather Bureau, the most complete report of its kind that is now available, but it includes other climatological data, and, for certain selected stations, determinations of average stream run-off compiled from the records of the Geological Survey. Although records of precipitation can never take the place of records of stream discharge, they are of great value in estimating the probable maximum, mean, and minimum discharge of streams in many localities. To be of greatest use, however, such records should be studied in connection with precipitation data collected in basins of streams whose discharge has been recorded for a number of years. Of special value to the engineer is the work of the Weather Bureau in predicting floods. The data assembled in connection with this work comprise many series of records of river stage, and include a great number of the longest and most valuable of such records available. Other meteorological data important in engineering investigations, including information in regard to temperature, evaporation, wind velocity, relative humidity, and electric storms, are also collected by the Weather Bureau.

General Land Office.—The primary function of the General Land Office is the subdivision, administration, and disposal of the public lands, and the Land Office maps of the many areas in the public-land states are the only ones that can be obtained. The plats showing the record and status of filings on the public lands in any district are open to inspection in the local land office, and those for the whole country are kept in the General Land Office in Washington. These records must often be consulted by engineers in connection with titles and rights of way.

Coast and Geodetic Survey.—The principal

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work of the Coast and Geodetic Survey is the mapping of the coast line of the country and the study of tidal currents, but this bureau also carries on systematic triangulation and leveling, which will eventually cover the whole United States and serve as a basis for the horizontal and vertical control of all governmental and other surveys. In performing this work it has assembled and adjusted the results of triangulation and leveling surveys made by other government bureaus, by railroad companies, and by private engineers whose work shows the required degree of accuracy. The magnetic charts of the Coast Survey also serve as a guide in all work involving the use of the magnetic needle.

Forest Service.—The work of the Forest Service pertains chiefly to the administration of the national forests, but it has resulted also in the accumulation of a large amount of information which is valuable to the engineer, such as is embodied in maps showing the nature and value of the forest, and in reports on water supply and allied subjects. Full co-operation with this bureau will greatly facilitate any engineering work in or adjacent to a national forest. The Service publishes regulations in regard to obtaining timber from the national forest, and the procedure necessary in connection with the development of water power. It maintains also an experimental departments, which makes large numbers of tests to determine the most economic use of timber.

Corps of Engineers, U. S. Army.—The Corps of Engineers has charge of the river and harbor improvements, the Lake Survey, the work of the Missouri River Commission and the Mississippi River Commission, and conducts such special miscellaneous investigations as are assigned to it. In the course of this work it has collected much information in regard to the topography of certain areas, stream flow, and water storage, as well as other data of great value to engineers, and it has designed and built many kinds of river and harbor improvements, such as dikes, jetties, storage reservoirs, and controlling dams and canalization. Many reports on the work of the Engineer Corps have been published, and much unpublished information is on file in the Washington affice and in the various field offices. A three-volume index covers the reports of the Chief of Engineers from 1886 to 1900.

Special Boards and Commissions.—Before appropriating money for any Government project, Congress often requires that its feasibility be considered by a special board or commission, which, for administrative purposes, is ordinarily attached to one of the executive departments. Boards dealing with engineering projects are, as a rule, placed under the War, Interior, or State departments. Reports of these boards or commissions are submitted directly to Congress and are usually published as congressional documents.

The following engineering boards are fairly permanent: The Mississippi River Commission and the Missouri River Commission, which work under the Corps of Engineers; the International Boundary Commission, directed by the State Department, which deals with the division of the waters of the Rio Grande and certain other questions at issue between the United States and Mexico, and the International Waterways Commission, also under the State Department, which deals with questions relating to the international streams between the United States and Canada. Special mention should also be made of the reports of the National Conservation Commission, which was appointed by Mr. Roosevelt, and in February 1909, made a special report containing a partial inventory of the natural resources of the United States. This report was compiled from records collected by the Government departments, which performed most of the work of compilation. The National Waterways Commission, established by Congress in 1909, has just finished a complete investigation of the various phases of development of the water resources of the country. Their report, based upon studies both in this and in foreign countries, will cover the relation of storage reservoirs to flood protection and as an aid to navigation, and the development and control of water powers.

Bureau of the Census.—Data in regard to social and industrial conditions in the United States are collected by the Bureau of the Census. Since 1870, statistics in regard to the power used in the operation of manufacturing establishments have formed a part of the statistics on manufactures. In 1902 the scope of these statistics was extended to cover central electric light and power sta-

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tions, street and electric railways, and telephone and telegraph business, so that a complete census of the manufacturing and electrical industries of the country is now made every fifth year. In addition to the statistics concerning the financial operation, number of persons employed, etc., the census reports contain many details concerning the size and equipment of plants and the character and quantity of power used. The first complete census of the electrical industry was taken for the year 1902, and the second covered the year 1907. The statistics cover all central electrical and power stations and every electric railway that was in operation during any portion of the respective census years. The relative use of steam, gas, and water power as prime motors in such central power stations was reported. No attempt was made to include statistics for the thousands of isolated electric plants. The statistics of the Census Bureau are tabulated and published in various forms, in order to present the material collected to the best possible advantage.

Bureau of Mines.—The principal function of the Bureau of Mines is the investigation of questions relating to the mining industries of the country. Many tests of various explosives have been made by this Bureau, and its special studies in connection with the use of fuels will be of value in the development of auxiliary stations.

Bureau of Standards.—The work of the Bureau of Standards is principally along experimental lines. The Bureau is equipped for many kinds of general study, both of materials and instruments, and its data will be of value in connection with the selection of machinery and material.

Other Government Bureaus.—In addition to the bureaus which make a specialty of gathering data of value to engineers, there are many others that incidentally collect information with which the engineer should be familiar. In the Department of Agriculture there are the Bureau of Soils, whose maps show not only the character of the soil, but also the topography of the area studied; the Bureau of Statistics, which gathers a large amount of information showing the industrial development of the country; and the Office of Experiment Stations, which collects much information in regard to drainage, irrigation, and other matters of interest to the engineer. In the Department of Commerce and Labor are the Bureau of Statistics, which collcts data that covers all lines of industrial development, and the Bureau of Corporations, which has just completed a report on the economic features of water-power development in the country, covering the demand for power, the amount developed, its ownership, and its relation to the public. This Bureau has also made an exhaustive report on terminal facilities in connection with water transportation. The War Department maintains an extensive laboratory at Watertown Arsenal under the Ordnance Office, where tests are made of structural materials for the Government.

Data Outside the Federal Government.—Attention should be called also to the work of states, municipalities, and private organizations which are carrying on investigations similar to those directed by the Federal Government. All the Western and many of the Eastern states have state engineers, whose functions, among other things, include the administration of the waters of the state. Many states have conservation commissions and geological surveys whose publications are of general value and may be obtained by applying to state officials at the various capitals.

How to Obtain Government Records

Government publications are, in general, classed either as congressional or departmental documents, and are deposited for distribution with the document rooms of the Senate and House of Representatives, with the bureau under which the work is carried on, and with the Superintendent of Documents.

House and Senate Document Rooms.—The document rooms of the Senate and House of Representatives are maintained primarily as the depositories for congressional records and such other reports as Congress may order printed. They contain, also, some departmental publications which are issued as congressional documents. Publications from this stock are distributed only on the order of members of Congress, to whom all applications for congressional documents should be sent. Neither the Senate nor House document rooms issues a list of publications in stock. They are, however, listed in the 'Monthly Catalogue' issued by the Superintendent of Documents.

Government Bureaus.—Most of the depart-

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mental publications deposited with the bureaus in which the work is done are distributed free of charge, but a nominal price is placed on certain issues in order that they may be obtained only by persons who need them and appreciate their value. Requests for information receive special consideration in all Government bureaus. In applying for data, the applicant should state precisely what he desires, and, in addition, should indicate the use which he hopes to make of the data. The average applicant for Government data expresses his needs so vaguely that he fails to receive much information which could be sent. Most Government bureaus issue complete indices, bibliographies, index maps, and other guides to the results of their work so that those interested can readily ascertain what is available. These reference publications should be included in the files of every engineer. Owing to the small editions of most publications, it is absolutely impossible to maintain even a small list of those to whom publications are regularly mailed. In place of such a mailing list, nearly all bureaus publish, at more or less regular intervals, lists of publications which are mailed to those interested in the work of the bureau. In general, requests for departmental data should be addressed to the bureau under which the work is done.

Superintendent of Documents.—All publications deposited with the Superintendent of Documents are sold, the price fixed being only sufficient to cover the cost of paper, press work, binding, and distribution. This nominal price prevents applications from persons who would not use the reports. This office acts as a conservator of papers, and is generally resorted to after other stocks have been exhausted. The *Monthly Catalogue, United States Public Documents*, issued by the Superintendent of Documents, gives a complete list of all Government reports issued during each month. In the list the publications are classified by the departments under which the work is done. The subscription price for this monthly catalogue is $1.10 per year. Other lists issued from time to time indicate the publications relating to certain topics or to the work of particular departments or bureaus. The scope of these catalogues is illustrated by the following lists, which are of special interest to the engineer:

List No. 18—Engineering: Mechanics. List of United States Government publications relating to electricity, fuel testing, structural materials, manufactures, river and harbor improvements, etc.

List No. 20—Lands. United States public documents relating to lands, irrigation and reclamation, conservation, forests, etc.

List No. 43—Forest Service publications.

List No. 48—Publications of the Weather Bureau and of the Signal Office.

List No. 53—Maps published by the United States Government.

Information concerning the titles of the various lists may be obtained by applying to the Superintendent of Documents, Washington, D. C.

Practically all Government publications are issued in small editions and can be supplied to comparatively few individuals. Great demand for some of them soon exhausts the supply. In order to make them generally accessible, copies are deposited in certain public libraries that have been designated as Government depositories. Some of these libraries receive all Government publications; others receive only papers relating to special subjects.

Another important source of information concerning Government work and publications is found in the local offices maintained by the Weather Bureau, the Geological Survey, the Reclamation Service, Corps of Engineers, the Land Office, the Forest Service, the Coast and Geodetic Survey, and other bureaus. A local office generally has a fairly complete file of all publications of its own bureau and may also have those of other bureaus. As a rule, these offices are in the Federal buildings of principal cities, but their location can readily be found in the local city or telephone directory.

In addition to the published data, there are many manuscript records available for consultation either in the Washington office or in the local offices of the various bureaus. In general, no lists or indices to these data are published, and they can be obtained only by applying to the various departments and stating clearly the information desired.

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Water-Power in California*

By J. H. WISE

WATER POWER, both potential and developed, has been the subject of investigations by a committee of the Commonwealth Club of California, of which J. H. Wise was chairman. The report is full and comprehensive and includes a discussion of the most feasible methods of state control of the appropriation of water for power purposes, and recommends legislation that will secure the following essential objects: (1) an

TABLE NO. 1

Stream drainage.	Minimum hp. in year	Min. hp. in 6 high-water months..	Additional hp. from storage...	Total for 6 month period	Average for year.
San Francisco bay drainage.....	2,653,600	6,443,200	1,501,400	10,598,200	5,299,100
North Pacific drainage.....	566,730	1,033,320	.....	1,600,050	800,025
Central Pacific drainage.....	880	16,740	14,390	32,010	16,005
South Pacific drainage.....	30,810	60,030	71,350	162,190	18,095
Interior drainage	240,680	347,700	206,870	795,250	397,670
Total for California.....	3,492,700	7,900,990	1,794,010	13,187,700	6,593,895

TABLE NO. 2

Stream.	Drainage.	Minimum hp. in year	Min. hp. in 6 high-water months..	Additional hp. from storage...	Total for 6 month period	Average for year.
Sacramento river.....	S. F. bay.....	2,020,800	3,829,200	712,400	6,562,400	3,281,200
San Joaquin river.....	S. F. bay.....	632,800	2,614,000	789,000	4,035,800	2,017,900
Klamath river	North Pacific..	534,900	967,600	.....	1,502,500	751,250
Minor rivers	North Pacific..	31,830	65,720	.....	97,550	48,775
Chief streams	Central Pacific.	880	16,740	14,390	32,010	16,005
Susan river	Interior Honey lake	2,350	3,330	15,300	20,980	10,490
Mono Lake streams....	Interior	21,750	84,520	32,800	139,070	69,535
Owens valley streams..	Interior Owens lake	213,700	255,810	142,000	611,510	305,755
Mohave river	Interior	2,880	4,040	16,770	23,690	11,845
Santa Clara river.....	South Pacific..	4,450	10,910	23,720	39,080	19,540
San Gabriel river.....	South Pacific..	5,270	8,050	1,470	14,790	7,395
Santa Ana river.....	South Pacific..	15,790	26,040	13,700	55,530	27,765
San Diego Co. streams.	South Pacific..	1,570	5,260	21,430	28,260	14,130
Minor streams west of Los Angeles	South Pacific..	3,730	9,770	11,030	24,530	12,265
		3,492,700	7,900,990	1,794,010	13,187,700	6,593,850

*Abstract from Transactions Commonwealth Club of California, June 1912.

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unretarded development of water power; (2) adequate service; (3) reasonable rates; (4) reservation of the original and increment value of water rights and public lands; (5) revenue.

The ultimate water-power development of California was studied in detail by W. B. Clapp, the district engineer of the U. S. Geological Survey, and in his report he divides the state into several natural drainage basins, as follows:

California.	Square miles.
San Francisco bay drainage	64,000
North Pacific ocean drainage	20,040
Central Pacific ocean drainage	11,250
South Pacific ocean drainage	11,490
Great Interior basin drainage	32,630
Colorado river drainage	18,950
Total area of state	158,360

His investigation included a study of all available records as to stream flow, storage possibilities, grades of the river channels, elevations as taken from the topographic maps of the Survey, and data secured from miscellaneous maps and reports of various state and other organizations. Mr. Clapp, in his analysis, considered the development for a six months' period, which has been reduced to an average for the year. He has further included the great interior basin and the Colorado river drainage under one head, interior drainage. The summary by drainage basins is given in table No. 1, while the possibilities of the chief streams, which are of more interest and greater value, are given in table No. 2.

The investigation shows that nearly five-sixths of the state's power is on the Sacramento and San Joaquin rivers and their tributaries. No attempt has been made to determine what proportion of the total is uneconomical for development, but it is obvious that a large percentage could not be constructed under the present conditions of low cost and abundance of fuel oil.

Of the 6,593,895 hp. available in the state, O. C. Merrill, chief engineer of the Forest Service, estimates that 4,872,700 hp. lies within the National Forests, and therefore under national control.

FOREST RESERVES

	Horse-power.
Angeles	18,000
California	10,000
Cleveland	11,800
Inyo	340,000
Klamath	210,000
Lassen	336,000
Modoc	13,600
Mono	193,300
Monterey	.....
Plumas	510,000
San Luis	.....
Santa Barbara	10,000
Sequoia	560,000
Shasta	360,000
Sierra	860,000
Stanislaus	688,000
Tahoe	577,000
Trinity	175,000
Total in forest reserves	4,872,700
Outside of national forests	1,721,195
Total for state	6,593,895

It is indeed significant and of considerable importance to note that, aside from the contemplated development which is in private ownership, the Forest Service has issued 92 permits as of March 1, 1912, which contemplate a total development of 981,270 hp. The outstanding permits are fairly well distributed over the entire state, with a preponderance of contemplated development in the Plumas and Lassen reserves.

A statement issued by District No. 5 of the Forest Service, which includes California and western Nevada, gives the following segregation of permits with the estimated mechanical installations:

Forest.	Number of permits outstanding	Est. av. annual output from low-flow horse-power	Est. capacity of mechanical installation (hp.)
Angeles	13	5,297	21,570
California	1	5,220	8,680
Cleveland	..	.....	.....
Eldorado (and Stanislaus)	1	14,100	23,300
Eldorado	1	.....	.....
Inyo	9	1,279	2,120
Kern	4	8,506	16,030
Klamath	..	.....	.....
Lassen	5	108,000	179,230

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Forest.	Number of permits outstanding	Est. av. annual output from low-flow horse-power	Est. capacity of mechanical installation (hp.)
Modoc	..	.....	.....
Mono	5	12,660	21,050
Plumas	9	156,400	410,902
Santa Barbara	4	236	393
Sequoia	3	6,500	13,340
Shasta	2	75	500
Sierra	16	84,240	152,725
Stanislaus	8	81,144	107,990
Tahoe	8	14,900	22,480
Trinity	3	670	960
Total	92	499,227	981,270

That California is exceptionally rich in water-power possibilities was brought out by M. O. Leighton in his study of the 'Undeveloped Water Powers of the United States,' and in his report published in Water Supply Bulletin No. 234, from which the table below is taken.

It will be noted from the table that the region furnishing by far the greatest water-power possibilities is the northern Pacific, which comprises essentially the basins of Columbia and Sacramento rivers.

California is the second state in the Union in point of total capacity of water-wheel-driven installations in active operation. A special census of the developed water-powers of the United States made by the Bureau of the Census shows this state's total capacity to be 466,774 hp. in 1909. The committee has accounted for 407,743 hp. hydro-electric development to date. There is, therefore, between 50,000 and 75,000 hp. in water-wheels direct-connected to miscellaneous mills, mining machinery, and privately owned plants. The ten states of largest development are as follows:

	Total Capacity.	No. of Wheels.	Av. Wheel Capacity.
New York	885,862	6513	136
California	466,774	1070	427
Maine	343,096	2797	123
Pennsylvania	290,990	5596	52

Principal drainages.	Drainage area in square miles	Flow per annum in billion cubic feet	Horse-power: Minimum	Horse-power: Assumed max. Development
North Atlantic to Cape Henry, Virginia	159,880	8,942	1,712,050	[1]3,186,600
South Atlantic to Cape Sable, Florida	123,920	5,560	1,253,000	1,957,800
Eastern Gulf of Mexico to Mississippi river	142,220	6,867	559,000	963,000
Western Gulf of Mexico west of Vermilion river	[2]433,700	2,232	433,760	822,600
Mississippi river (tributaries from east)	333,600	12,360	2,619,590	[1]5,344,600
Mississippi river (tributaries from west, including Vermilion river)	905,200	9,580	3,948,970	7,085,000
St. Lawrence river to Canadian line	[3]299,720	8,583	6,682,480	8,090,000
Colorado river above Yuma, Arizona	225,000	521	2,918,500	5,546,000
South Pacific to Point Bonita, California	70,700	2,193	3,215,400	7,808,300
North Pacific	290,400	15,220	12,979,700	24,701,000
Great Basin	223,000	.....	518,000	801,000
Hudson's Bay	62,150	614	75,800	212,600
Total	3,269,489	70,672	36,916,250	66,518,500

[1]Not including area in Pennsylvania.
[2]Includes Rio Grande in Mexico.
[3]Includes drainage in Canada.

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Massachusetts ..	260,182	2749	95
Oregon	231,379	590	392
Wisconsin	220,916	1667	132
South Carolina..	207,242	1301	159
Michigan	205,019	1498	135
New Hampshire.	183,167	1799	102

As previously stated, there is in active operation in California 407,743 hp. of hydro-electric machinery. This total development is classified into two main subdivisions: (1) plants with conduits or power-houses situated entirely or in part on Government land within the national forest, and (2) plants outside of the forest boundaries or on patented land within the reserves.

Legislation

The subject of legislation was made a special study by a sub-committee of which O. C. Merrill, chief engineer of the Forest Service, was chairman. His report, which as below, includes notes and observations pertinent to water-power regulation, with recommendations for legislation along definite lines.

The development, transmission, distribution, and sale of electrical power for general commercial use is a quasi-public business, which the state has authority to regulate. The use of water and of public land

Plants with Conduits and Power-house Sites Entirely or in Part on Government Land Within National Forests

	Name of Plant.	Capacity of Machinery (hp.).
Southern California Edison Co.	Kern River No. 1	26,810
	Mill Creek No. 1	1,005
	Mill Creek No. 2	335
	Mill Creek No. 3	4,020
	Lytle Creek	670
	Santa Ana No. 1	4,020
	Santa Ana No. 2	1,340
Pacific Light & Power Corporation	Borel	13,405
	Mentone	2,010
	Sierra	804
	Azusa	2,010
Los Angeles Aqueduct	Cottonwood	2,010
	Division Creek No. 1	201
	Division Creek No. 2	804
Nevada-California Power Co.	Plant No. 2	8,040
	Plant No. 4	8,040
	Plant No. 5	2,010
The Hydro-Electric Co.	Plant No. 1	2,010
San Joaquin Light & Power Corporation	San Joaquin No. 3	2,680
	New San Joaquin	21,400
	Bakersfield Cañon	1,810
Mt. Whitney Light & Power Co.	Tule River	2,680
	Kaweah No. 1	1,810
	Kaweah No. 2	2,010
Tuolumne Electric Co.	Tuolumne	805
Sierra & San Francisco Power Co.	Stanislaus	45,500
	Phoenix	2,510
Utica Gold Mining Co.	Plant near Murphy's	2,010
Northern California Power Co.	Snow Creek	1,610
	Cow Creek	2,010
Western States Gas & Electric Co.	Weaverville	2,010
Oro Water, Light & Power Co.	Lime Saddle	2,680
Miscellaneous		3,000
		174,069

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PLANTS OUTSIDE OF FOREST BOUNDARIES OR ON PATENTED LAND WITHIN THE RESERVES

	Name of Plant.	Capacity of Machinery (hp.).
California & Oregon Power and Light Co...	Falls Creek	3,680
	Shasta River	480
Northern California Power Co.	Inskip	8,040
	South	5,360
	Kilarc	4,020
	Volta	8,900
	Coleman	16,100
Oro Water, Light & Power Co.	Coal Cañon	1,340
Pacific Gas & Electric Co.	De Sabla	17,400
	Centerville	8,575
	Colgate	20,000
	Deer Creek	7,370
	Alta	4,020
	Newcastle	1,075
	Electra	26,810
	Folsom	5,020
Sierra & San Francisco Power Co.	Knight's Ferry	2,010
Pacific Light & Power Corporation.	Pedley	804
	Highgrove	134
Ontario Power Co.	Ontario	1,005
Mt. Whitney Power & Electric Co.	La Grange	1,210
Truckee River General Electric Co.	Fleish	2,680
	Farad	2,010
	Verdi	4,020
	Washoe	2,010
	Reno	940
Western States Gas & Electric Co.	American River	4,020
Holton Light & Power Co. (Imperial valley)	Holtonville	1,740
Coast Counties Light & Power Co.	Big Creek	1,055
Snow Mountain Power Co.	Potter Valley	8,700
Great Western Power Co.	Las Plumas	53,610
Mariposa Commercial & Mining Co.	Bagby	536
Miscellaneous		3,000
Total		227,674

for the development of such power is a public use, and may also properly be regulated by public authority. Regulation of the business of public utilities can properly be directed toward two objects only: adequate service and reasonable rates. Adequate service comprehends the furnishing of the quantity of power desired at such time, in such form, and under such conditions as the user may desire. Rates, to be reasonable, must not exceed the value of the service to the user. Such value of the service should be based upon the cost at which the users in any given district, either individually, by association, or by incorporation —public or private—could, under average conditions, secure for themselves the same or equivalent service, plus such an amount in addition to cost as would be necessary to induce capital to invest in the enterprise.

The regulation of the appropriation and use of water and of public land may properly be directed, in addition to the above objects, to the reservation in the public of the original and the increment value of water rights and of public lands, and to the raising of public revenue from the use of such rights and lands. Such objects, however, should be subordinate to the primary objects of service and rates, and the four ob-

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jects named should have precedence in the following order: (1) adequate service, (2) reasonable rates, (3) reservation of the original and increment value of water rights and public lands, and (4) revenue.

Any provision of a proposed or existing water law should be considered in its bearings, either directly or indirectly, upon the four objects named above, and nothing should be included in any law that will not tend to secure one or more of these objects, without, at the same time, serving to hinder a higher object. Appropriations of water for power purposes should not vest in the appropriator a perpetual right in and title to the use of water. Sufficient consideration is given the appropriator if his investment is protected against confiscation and uncertainty of tenure, and these can be adequately provided for by the issuance of a license or franchise. To do more takes from the public both the original and the increment value of the water right without a corresponding advantage, either in better service or in lower rates. The probability is that granting a perpetual right would increase rates, since the title to the water right would undoubtedly be capitalized and the tendency would be to make rates sufficiently high to earn dividends on such capital, although it represented no actual investment.

Licenses may be either for a fixed term, for a renewable term, or be indeterminate. If for a fixed term, the shorter such term is the higher will be the interest and discount rates, the greater will be the excess of capital cost over actual cost, and consequently the higher will be the annual percentage that capital charge will bear to all other charges. A fixed-term license will require amortization of the capital cost during the term of the license, and the shorter the term the greater the annual amortization charge. Both of these features of a fixed-term license tend to increase rates without any compensating public advantage. Furthermore, as the termination of the lease approaches, improvements to plant will be neglected on account of the practical impossibility of amortizing the cost of such improvement in a few years' time. The result will be deterioration of plant and impairment of service, with no compensating public advantage. A renewable-term license is merely equivalent to a longer fixed term unless successive renewals may be made indefinitely. Such a license is subject to the same objections, in kind, as the fixed-term license, but in degree the objections are as much less as the aggregate term is longer. The terms of a license of this kind could be arranged to so reduce the objections, quantitatively, that none of the four objects named would be impeded, though none would be served.

A lease indeterminate in duration, so long as the laws and terms of the lease are observed, or until the state or municipality, or some other public corporation, shall take over the lease and the works constructed thereunder, at a reasonable valuation for the latter, furnishes full security to the capital invested, supplies the best conditions for securing proper service and reasonable rates, and reserves in the public the original and the increment value of the franchise itself.

Licenses should not issue as a matter of right to anyone who may apply therefor, but the law should provide that licenses shall not be given if there is conflict with a prior application or license, if it is patent that there is no water subject to appropriation, if the applicant fails to comply with the regulations made in pursuance of law. An administrative board should be given discretion to refuse a license whenever the granting of the same would be detrimental to the public interest.

If licenses are issued for a definite term, the terms should not be subject to change by later legislation, nor should any other conditions be changed unless specific provision therefor is expressed in the law or in the license. If renewable licenses are issued, it will be preferable to have the general condition and the term of renewal expressed in the statute and in the license. To make a renewal wholly subject to law existing at the time of renewal, nullifies any advantage of a renewable license over a fixed-term license. If a license is indeterminate, the general conditions should be fixed from the beginning. Minor conditions—rentals, taxes, etc.—may properly be left subject to periodical adjustment or modification.

If licenses are to terminate at the end of a fixed period, unless the term is made very long, it is absolutely essential that provision be specifically made for the disposition of the works constructed or operated in connection with the license. The

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state should guarantee either that it will take over all the works itself, at an appraised valuation, or that, if the license is issued to another than the original licensee, the new licensee will purchase the works at appraised valuation. Such an appraisal would naturally be made by the State Railroad Commission. The appraisal should fix the physical valuation of so much of the works as are used and useful in the business of the public utility, should allow for reasonable promotion expenses, and should include capitalization of interest charges during construction, but should not include any valuation for the license or any other franchise granted by the state or local authority unless a purchase price has been paid therefor. Capitalization of deferred earnings should not be included in the valuation, but in lieu thereof a bonus should be paid in the form of a percentage of the appraised valuation, such percentage to be in inverse proportion to the time that the license has run—as, for example, ½% for each year less than forty that the license has been in existence.

The license, if indeterminate, should be subject to the rights of the state to require that the works be properly maintained, that they be operated to a reasonable percentage of full capacity, and with a reasonable continuity, on penalty of forfeiture of the license, and should be subject to the right of the state to regulate the rates and character of service. The works should be subject to purchase at any time at an appraised valuation, either by the state, by the municipality, or by a publicly organized irrigation, water, or power district. Condemnation proceedings should not be required, but upon vote to purchase, in the manner prescribed by law, the Railroad Commission should be directed to appraise the value of the works to be purchased and the utility should be required to make the sale upon the tender of the appraised valuation, subject to the usual right of appeal to the courts from the valuation as fixed by the commission.

Licenses should not be transferable prior to completion of the works, except upon the specific approval of the administrative board. Such a procedure would prevent, in large measure, the far too prevalent practice of the hold-up of legitimate enterprises by water-right speculators for the purpose of selling what there is no intent of using. Licenses should not be transferable prior to completion of the purpose for which the license was issued, also for violation of the essential terms of the lease or of the law under which the lease is issued. Violations that do not go to the essense of the license should be penalized without cancellation of license. Cancellation should be made and penalties fixed by the administrative board under the terms of the law and subject to appeal to the courts. Violation of any other law, or the fixing of penalties for failure to comply with the findings of another board will be outside of the jurisdiction of the Board of Water Control.

Before granting a license, map, plans, and other data should be required in sufficient detail to permit of determining whether the site will be completely developed, whether the structures will be safe, and whether they are so designed as to make an economical use of the water. The board should have authority to require modification of plans whenever necessary to secure any one of the above.

When plans have been approved by the board, no substantial change should be allowed unless approved by the board, and the board should be empowered to require that construction be done in conformity with the approved plans. Sufficient supervision should be exercised over the construction to insure this.

It is the opinion of the majority of the committee that no charges should be made for the use of water-power sites or water rights for the purpose of raising general state revenue. It is believed, however, that charges in the form of either filing fees or annual rentals, or both, should be collected, sufficient to defray the cost of the administration of the water laws and the salaries of the board and its employees.

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Measuring Steam Currents in Underground Pipes*

By CARL HERRING

THE measurement of stray electric currents flowing through buried conductors, such as pipes, and generally originating from an electric railroad or other grounded system of electric distribution, is attended with various difficulies, particularly in the determination of the current which enters or leaves the underground pipe through the surrounding earth, and as it is the current which leaves a pipe in this way that corrodes it electrolytically it becomes important to be able to locate and measure that current. Another important measurement is to identify the original sources of the stray current.

One of the problems is to measure the currents in a pipe and to find and measure the currents leaving it through the earth, by methods which are positive and not based on any questionable assumptions, and the results of which could be used as reliable evidence in court. Another is to identify the source of the stray currrents flowing in pipes so as to establish the responsibility for them in legal proceedings.

The usual method which consists in measuring the drop of potential in millivolts between the two fixed points on one length of pipe exposed for that purpose, and then calculating the current from an assumed resistance of the pipe, will not answer the requirements, as the resistance of the pipe is a mere assumption which may be far wrong, even when based on measurements of other presumably similar pipes before they are laid. A little thought will show that such a test at best is only a crude one and the results would not be likely to stand the usual attacks in court proceedings. Even though many pipes may have been measured before laying and found to agree fairly well, there is always the uncertain factor of the wall thickness of that particular piece of pipe in service on which the drop of potential was taken.

After trying out numerous other methods the following were found to be the best and were the ones actually used in work that I have done:

The fundamental principle is as follows: Let *P*, Fig. 1, be a part of an underground pipe which has been uncovered and through which an unknown current *I* is flowing as shown; at first let it be supposed that this current is steady, and of course a direct current. Let *D* be a sensitive galvanometer, millivoltmeter or any other form of detector of small differences of potential, connected as shown; there should preferably be no variable resistance like an unbonded pipe joint between the two contact points. Let *A* be an ammeter, *B* a few cells of accumulators, and *R* an adjustable resistance; the shunt circuit containing them is connnected as shown anywhere outside of the points of application of the voltage detector, the farther away the better—they may even be on the other side of a joint.

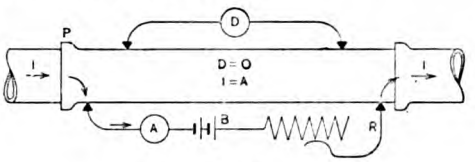

FIG. 1.

To find the current flowing in the pipe adjust the resistance *R* until *D* reads zero; then there will no longer be any current flowing in the shunted part of the pipe, hence the reading of the ammeter will give the current *I* in the pipe. The current may be said to have been sucked out of the pipe by the battery, and made to flow through the ammeter, where it can be measured; as far as the current in that short section is concerned the pipe circuit has in effect been electrically cut in two as though an insulating joint had been introduced.

If *D* is a galvanometer with proportionate deflections, instead of a mere detector, then by taking a deflection after the shunt circuit has been opened a reading proportionate to the drop voltage for that current will be obtained. The instrument *D* is thereby calibrated to read the pipe currents directly and can be used for this purpose thereafter; the test with the battery current is therefore merely of the nature of a preliminary calibration, and need be carried out only once for each station.

*Abstract from Proceedings American Institute Electrical Engineers, June, 1912.

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If, in addition, this voltage instrument is calibrated to read directly in volts, usually in terms of milli- or microvolts as for instance a millivoltmeter, then if the deflection reduced to millivolts is divided by the current it will give the resistance of the pipe in milliohms between the two points of application of the voltmeter, hence it enables the true resistance of the pipe to be measured.

In most cases it is advisable to make these connections for the voltmeter permanent and to bring wires from them to the surface before filling in the hole, being careful to mark one of them with a knot, for having once obtained the constant from this test with care, the current in the pipe can be measured any time thereafter, correctly and very simply with a mere millivoltmeter. The most convenient form of this constant is the amperes per millivolt, which is the conductance in millimhos.

The current which leaves or enters a pipe between any two points or stations can then be determined by making this calibration at each of the two stations and then taking simultaneous readings of the currents in the pipe at the two stations with two millivoltmeters or calibrated galvanometers; the difference between these currents will then show the amount of this current, and whether it is leaving or entering.

In the method shown in Fig. 1 there should be no current leaving or entering the pipe between the points of application of the shunt, hence the hole should be free from water and there should be no moist earth in contact with that part of the pipe.

It is assumed in this method that the short length of pipe between the shunt contacts is too small a fraction of the whole circuit of the pipe line currents to alter these currents when that section is practically cut out of the circuit, as it is when the current flows through the shunt. This assumption is probably absolutely safe in all cases in practice.

As this method is not in any way concerned with the nature of the circuit beyond the single pipe length under test, nor with the rest of the path of the current, it can be applied to the most complex network of pipes, even when the pipes are interconnected together elsewhere or bonded to the track.

In measuring the pipe resistance by this method, or in general when the voltage drop is measured, it is of course assumed that the current is constant while the two successive readings are taken, hence it is recommended to repeat the two readings a number of times. When this constancy of current cannot be asssumed, one of the modifications of this method described below may be used.

A portable millivoltmeter with a full scale deflection of 10 millivolts has divisions of 0.1 millivolt, hence can be estimated to 0.01 millivolt. If a 16-in. (40.6-cm.) cast iron pipe has a resistance of about 0.00001 ohm per foot (30.5 cm.), then say 5 ft. (1.5 m.) will give a drop of half a divison per ampere. This will give a rough idea of the range of measurements that can be made with a millivoltmeter. Improvements may perhaps also be made in these instruments to make them still more sensitive.

When a portable galvanometer is used instead of a millivoltmeter in order to get greater sensitiveness, like the mirror and telescope galvanometers that I used in these tests, it is necessary to calibrate it for the volts while in place before each test, hence a convenient way of doing so should be provided. With the accumulator, ammeter, and rheostat available in this test, this is easily done by passing a known current through a known low resistance, given a known drop which is then used to calibrate the instrument. Such a galvanometer should be provided with the usual shunts, and if so it can also be calibrated with a millivoltmeter which is always at hand for such tests.

When such galvanometers are made extremely sensitive, as would be desired for instance when the pipes are very large and thick or the current very small, they are apt to have a loose zero or give somewhat indefinite deflections. Attention is therefore called to the fact that small deflections, when they are very definite and when the instrument has a rigid zero, as in a good portable millivoltmeter, may be more accurate and reliable than larger deflections in a galvanometer that is more sensitive but has a loose and unreliable zero and less definite or not strictly proportional deflections. Instead of using exceedingly sensitive instruments it may be better to use greater lengths of the pipe, even to the extent of including a joint, which in that case should preferably be bonded so that it is not variable. In practice there are various very desirable modifi-

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cations of the method which is shown only in its simplest form in Fig. 1.

Insead of attempting to adjust the current in the shunt to bring the voltage *D* to zero, it is far more convenient to use a regular measuring instrument for *D* instead of a mere zero detector, and then to pass a definite current through the shunt, say 10, 50, or 100 amperes, and read the two deflections of *D* when this current is on and off; this had best be repeated several times. The difference between these two readings then corresponds to that current, from which data the instrument can be calibrated to read in amperes. The best current to use is that which will reduce the original deflection as much as possible. By using the difference between a large and a small deflection the errors due to a loose zero, which are common with highly sensitive instruments, are reduced.

This method also has the advantage that an observer can read both *A* and *D*, as he first adjusts the rheostat to give the exact predetermined current and after that can open and close the switch to throw this current on or off, without having to read the ammeter, this current being absolutely constant. He need, therefore, read only *D*.

All the above applies to steady currents or to such as are steady long enough (a few seconds) to make two successive readings, as the voltage drop and the current cannot be measured simultaneously in the form shown in Fig. 1. In practice such stray currents are likely to vary continuously and often vary rapidly. By waiting for a suitable opportunity when the current is practically constant for a short time, measurements of sufficient accuracy can often be made, and as this part of the test is only for the calibration, hence of a preliminary nature and needing to be made only once for each station, one is justified in taking more time for it. It may be facilitated by using an extra voltage detector applied somewhere outside of the shunted part (as in Fig. 3) and having an additional observer to call out when it is steady or to note whether or not it had been steady while the other pair of readings was taken.

When, however, the fluctuations are too rapid, the following modification can be used; it proved to be very satisfactory in practice, although somewhat more cumbersome, and requiring additional apparatus, though no more observers.

Let the left hand side of Fig. 2 represent the same arrangement as in Fig. 1. A second voltage detector *D* is then added as shown; it may be a sensitive galvanometer and need not be calibrated. *S* is a second shunt circuit containing a battery and an adjustable resistance which is operated by the observer of *D*, who keeps adjusting it continuously so as to maintain the deflection

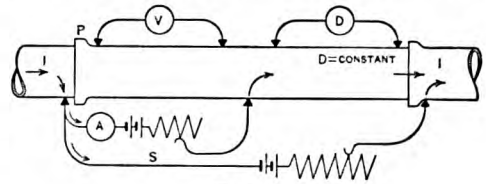

FIG. 2.

in *D* constant. During that time the current will be steady for the other observer, who then completes a set of readings with the other instrument *V* according to the method shown in Fig. 1.

The purpose of the additional shunt *S* is to take up all the excess of the pipe current above a certain amount, thus acting as a sort of overflow, taking care of the peaks only. The observer of *D* must, therefore, use some judgment in selecting the deflection at which the current is to be held constant; it should be kept at about the base of the average peaks, but should not be too low for the other observer to get good readings for his calibration. It may be a different deflection for each set of readings of the other observer; the only important point is that the current should be held constant in that length of pipe for a long enough time to take two successive readings, requiring only a few seconds. Or, if practicable, the observer of *D* could shunt off the whole pipe current, thus making *D* read zero, and leaving the pipe entirely free from current for the other observer to make his calibration or any other test for which it is required to have the pipe free from current.

The adjustable resistance for this extra shunt *S* should be made of a pile of carbon plates which are compressed by means of a lever so that the observer of *D* may quickly follow the variations of the current with it. Very good results were obtained with such an arrangement after a little practice. As the observer of *D* knows whether or not the current has been successfully kept constant he

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can discard the readings of the other observer for which the surrent had not been constant. By taking the mean of a number of good readings, very satisfactory results were obtained.

Having thus calibrated the voltmeter *V* at each of two neighboring stations, the currents which enter or leave the pipe between them may be determined, with the fluctuating currents, by taking the readings of the two instruments simultaneously by means of visual or telephonic signals, preferably at times when the currents are momentarily steady.

This method showed the serious errors which might arise by using the older method based on the assumed resistance of the pipe, it being often impossible to state after the pipe had been laid and was in service what thickness the particular piece under test had. In the present case those who made the electrical tests of this pipe line had not been informed that the pipe varied greatly in thickness.

Another modification of the method for use when the currents are very unsteady is

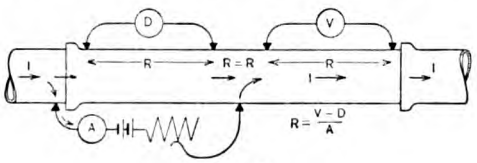

FIG. 3.

shown in Fig. 3. The apparatus is similar to that in Fig. 2, except that the additional shunt with its battery and rheostat is not required, but on the other hand three observers are required instead of two. The positions of *D* and *V* are now reversed, the important instrument *V*, to be calibrated, being now placed beyond the shunt, while *D*, which may be a mere indicator or galvanometer, is connected to the points within the shunted part. The resistances *R* and *R* need not now be equal as marked on the diagram.

The shunt current is first adjusted to some convenient average value of that flowing in the pipe, then as the latter fluctuates on both sides of this value there will be times when it is exactly equal to it; this is indicated by *D* reading zero, and at that moment the observers of *A* and *V* take their readings. This can be repeated for different currents. The quotient of *A* divided by *V* should then be constant for all the readings; this calibrates the instrument *V* as it gives the amperes per division, and it can therefore be used as a pipe current ammeter thereafter.

This method was not tried. It requires a battery, leads, and connections large enough for the whole pipe current, and a constant flow of the current for a long enough time to get a good number of readings; this may sometimes require rather large battery and leads. But if the observer of *D* manipulates a carbon plate rheostat rapidly to keep the instruments at zero, it ought not to take long to get a group of good readings.

If in this method shown in Fig. 3, the instrument *D* is also a measuring instrument instead of a mere zero detector, then the following modifications can be used. The two instruments *D* and *V* need not then be calibrated in volts, hence they can be two uncalibrated galvanometers, provided only that they are exactly alike in giving the same deflections when connected in multiple; they may be adjusted to do so by a series resistance. Two good millivoltmeters would do in cases in which the deflections are large enough and accurate enough so that their *difference* may be relied upon as being an accurately measured quantity, for the present modification of the method is based on measuring this difference.

Having two such instruments, adjust the points of contact for either *D* or *V* so that the two instruments always read alike for the pipe current alone, however fluctuating that current may be. This, of course, must not be done by an adjustable resistance in the circuit of the instrument, but by moving the contacts on the pipe, hence this method cannot be used directly when all four of these contacts are drilled or soldered, although it may then be used indirectly, as shown later. Three of them may be permanent and the adjustment made with the fourth.

Such connections mean that the two pipe resistances shunting these instruments are equal, as any current then gives the same drop in both. If now any known part of the current be sucked out of the pipe by the battery shunt as before, then, as the two resistances are equal, the difference between the readings *D* and *V* must correspond with the difference between the two currents in these two parts of the pipe, and this differ-

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ence between the two currents is of course equal to the known battery current *A*. Hence dividing this known battery current by the difference between the two deflections, calibrates both of the instruments for reading pipe currents thereafter; that is either of them will give the amperes per unit deflection. It is precisely like the method described above, except that the two readings which then were necessarily successive are now simultaneous.

It will be noticed that as only the difference between the two currents is now involved, and is this difference is always constant, the method does not assume even a momentary constancy of the pipe current, being entirely independent of it; this current in the pipe may therefore fluctuate over wide ranges, the only important point being that with such fluctuating currents the two readings must be taken simultaneously. And as the calibration depends on the difference between two readings, the larger one should be as large as possible and the smaller one as small as possible, hence the battery current should be made as nearly equal to the pipe current as practicable.

As the battery current in the shunt is in practice governed entirely by the adjustable resistance in that shunt circuit, this local current will remain constant no matter how much the pipe current varies. Hence it can be adjusted and noted prior to the taking of the two simultaneous readings, thus saving one observer. Moreover, this shunt current can be adjusted to any convenient number of amperes, 10, 20, 50, etc., so as to simplify subsequent calculations.

As before, the above measurements will also enable one to calculate the resistance of those parts of the pipe which are embraced by these two instruments, provided the latter are calibrated to read in volts, and are not merely deflection instruments. The readings in millivolts, divided by the known currrents in amperes then give the pipe resistances in milliohms.

If it is not convenient to adjust the contacts on the pipe so that the readings of the two instruments are alike, the inequality of these readings may be allowed for by calculation. For simplifying the rough mental calculations which a careful testing engineer should always make during a test to see that there are no grave errors, wrong connections, or inconsistencies, it is advisable to make the two distances between the pairs of contacts approximately equal so that the ratios between the deflections will be approximately unity.

A preliminary test is then made to determine this correction factor accurately. This is done by taking a series of simultaneous readings on the pipe current only, or if too small, then supplemented by the battery current which should then be reversed, so as to add to instead of deducting from the pipe current, and it must of course now flow through both pieces of pipe, and not as shown in the figure.

From this preliminary series of readings a good average value can be obtained for the ratio of the readings of *D* divided by the corresponding ones of *V*. Call this *n*. Then all subsequent readings of the instrument *V* in the main test must be multiplied by this correction factor *n*, to reduce them to what they would be if the two pipe resistances had been equal as at first described.

In general the modifications shown in Fig. 2 and 3 have the disadvantage, as compared with that in Fig. 1, that they require an exposure of a larger part of the pipe; the alternative of using shorter lengths for each instrument is not recommended—these lengths should be as great as conditions permit, preferably each a whole pipe length.

The other test referred to in the introduction concerns the identification of the source of the stray currents in the pipes. This is often important in legal proceedings, for even if currents are shown to be flowing in pipes the question of where they come from still remains.

The method that I devised, and used very successfully in a large number of tests, consists in taking a series of many simultaneous readings of the drop of potential or the current, in the pipe and in the track of the supposed source, especially the extreme high and low readings of the fluctuations, and plotting them together on the same sheet of cross-section paper, using different scales if necessary to make the average ordinates nearly equal. If the prominent peaks and troughs of these two saw-tooth curves then correspond approximately with each other, there is no doubt that both the currents originate from the same source. If the curves are radically different, then that track is either not the right source or at least is not the only one.

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In the tests referred to, these identification measurements were made over long stretches of several miles, with the aid of telegraph wires, but it is possible that good results could also be obtained in certain cases with millivoltmeters applied to stretches short enough not to require the use of long telegraph wires. The readings need not be in volts or amperes. They merely need to be proportional to them; hence the instruments need not be accurately calibrated, but should give correct proportional deflections. Nor need the resistance of the telegraph wire leads be taken into account.

As the above described methods for measuring the pipe currents and resistances are entirely independent of the rest of the pipe circuit or the rest of the path of the current, they may also be applied to other tests than those of underground pipes, in which the rest of the circuit is also unknown or inaccessible, as, for instance, in measuring the resistance of a part of a circuit such as a bus-bar, a permanently connected shunt, etc., through which current is flowing and which is in service and can therefore not be cut or have its current interfered with. Or the current may be alternating. There are, of course, numerous other modifications of the same general principle, which may be made in special cases.

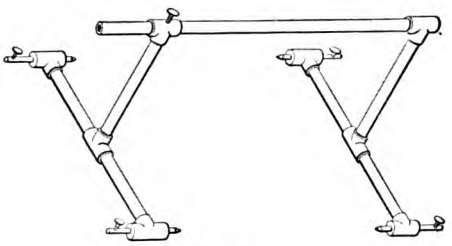

FIG. 4.

The apparatus used for the pipe current tests consisted of two portable, low resistance, suspension coil, mirror and telescope galvanometers on tripods, of the type used for outdoor insulation tests, with the usual set of shunts, but made very sensitive, as the original requirements were to include measurements of even relatively small currents in rather large pipes. Their constants were about 0.001 millivolt per mm. For ordinary work they would not need to be so sensitive. Probably in many cases two sensitive but reliable millivoltmeters would be sufficient to carry out the above mentioned tests; if so, they are, of course, decidedly preferable on account of their portability, especially when high speed automobiles are incessantly passing along the road uncomfortably close to the instrument and observer.

The rest of the apparatus consisted of a wire rheostat, a reversing switch, a small portable two-cell accumulator capable of giving about 100 amperes, and a millivoltmeter with several shunts to be used as an ammeter also, all conveniently mounted in a portable box serviceable also as a writing table. A single cell would probably have answered nearly as well. For the preferred form of test shown in Fig. 2 there was in addition a carbon plate resistance with a lever for quick and strong compression, a second set of two cells of accumulators, and a sensitive millivoltmeter.

The form of the universal clamps finally adopted for making the contacts with the pipes is shown in outline in Fig. 4; these clamps proved to be very convenient. They spanned the pipe, making contacts for the same lead at two diametrically opposite points. The contact pins were made with hardened points which with a light hammer blow entered the pipe slightly and made serviceable contacts even for currents of 100 amperes. These pins were insulated from the frame so that they could be used for different circuits if desired. The clamps were made of light bicycle tubing and ordinary T-joints, making a simple, convenient, and inexpensive rig.

Cylinder Performance of Reciprocating Engines

PERFORMANCE of reciprocating engines is popularly supposed to have been definitely established for many years. The various phenomena and formulae applicable to the action of steam in the cylinder of reciprocating engines as they exist today have always been considered by engineers as being so firmly established as to be hardly worth further investigation and analysis. The University of Illinois Engineering Ex-

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periment Station has just concluded an exhaustive series of tests conducted under the direct supervision of J. Paul Clayton, the results of which are embodied in the *University Bulletin* of May 6, 1912. A single-cylinder, 12 by 14-in. Corliss engine was selected for the tests for the reason that in this type of engine all the steam used passes through the cylinder. The forms of the expansion and compression curves were the objects of study, the influence of varying points of cut-off being determined by transferring the indicator diagrams to logarithmic cross-section paper. The value of n in the equation of the polytropic curve $PV^n = C$ becomes the slope of the expansion or compression curve, the equation being a straight line when plotted on logarithmic cross-section paper. It has been discovered that the law $PV^n = C$ holds substantially for expansion and compression, and from this fact certain rational methods have been developed for approximating the clearance volume, of locating the cyclic events, and of detecting moderate leaks when the engine is in operation. It has been discovered that the value of n for the expansion curves of steam diagrams bears a definite relation in any given cylinder to the proportion of that weight of the steam mixture which was present as steam at cut-off. This proportion has been designated x_c, and its relation to n for the same class of cylinder as regards jacketing has been found to be practically independent of engine speed or cylinder size. The significance of the discovery of this relation is that there is now available an accurate method of approximating the value of x_c and consequently the actual weight of steam and water present at cut-off, from the indicator diagram alone.

The following conclusions have been drawn from the results of this investigation, as applicable to non-jacketed steam cylinders in good condition exhausting at or near atmospheric pressure, and with the limitations imposed:

1. At a given initial pressure and speed of engine there is a definite relation existing between x_c and n, in any one cylinder, which is practically independent of the cut-off position.

2. This relation is practically independent of cylinder size and of engine speed; it is therefore applicable to other cylinders of the same type.

3. By means of the experimentally determined relations of x_c and n, the value of x_c may be approximated from the average value of n obtained from the expansion curves of one set of indicator diagrams, taken simultaneously; therefore the actual weight of steam present in one revolution may be approximated.

4. The actual steam consumption may be obtained by this method from the indicator diagram to within an average of 4% of the amount consumed as measured by test.

5. This method has the following advantages not possessed by tests: it is more accurate than the average test and is the most accurate method available for testing certain classes of engines; it virtually measures an instantaneous rate instead of an average quantity over a long time, and thus enables a large number of points to be obtained for a water-rate curve; it permits of making tests at frequent intervals instead of once in the engine's life; the expense is not to be compared with that of an equally accurate test; it involves no change in the routine of the plant tested.

Mr. Clayton gives an exhaustive study of the use of the logarithmic diagram as applied to all elastic media and calls attention to the many common errors made in analyzing steam-indicator diagrams of which the following are worthy of note:

The values of n for the expansion curves of steam indicator diagrams are not closely constant, but are subject to a very wide range of variation. The range of variation found in the present investigation is from 0.70 to 1.34. The range of values in the engine tested was from 0.835 to 1.234. The average values were 0.947 for the tests run with saturated steam, 1.056 for the tests run with superheated steam, and 1.004 for all tests. The values of n for most engines of ordinary size using saturated steam at normal cut-off is between 0.95 and 1.05, while for superheated steam the range is usually from 1 to 1.30. For saturated steam the value of $n = 1.0$ is about an average value. The explanation of the value $n = 1.0$ can be seen from the results of the tests given. The only meaning that the average value of $n = 1$ ever possessed is that the average of x_c, in the class of engines examined, lies in the range between 0.60 and 0.70.

The law of Boyle or Mariotte, or the law of isothermal expansion of a perfect gas,

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has no bearing of any kind whatsoever on the expansion of steam in a cylinder. The equilateral hyperbola sometimes occurring in steam cylinders is only a special case of expansion according to the polytropic law $PV^n = C$, while Boyle's law is another special case which never occurs in steam-engine practice. Because of the agreement in form between Boyle's law and the equivalent hyperbola (the special case of the law, $PV^n = C$, where $n = 1.0$), this latter curve has been called the ideal or theoretical curve of expansion to which curves in practice are supposed to approach as a measure of practical perfection in the use of steam. The equilateral hyperbola is in no sense whatsoever an ideal or theoretical curve, and its use for the purposes of comparison is an empirical or arbitrary convention only. It should be called the conventional expansion. It has ever been contended that because an expansion curve did not coincide with the equilateral hyperbola, some grave fault exists in the engine. A value of n may be as low as 0.60 with no graver fault than very excessive initial condensation, while a value of 1.35 may be found from no graver fault than that of using steam superheated about 250° Fahrenheit.

The only rational use of applying the equilateral hyperbola to steam PV-diagrams is to act as a guide to see whether n is greater or less than 1.0. If the actual curve is not close to this hyperbola, if no faults exist, and if the cylinder is nonjacketed, then this fact means that the value of x_c for the case examined is less than about 0.60 or greater than about 0.70. The assumption that $n = 1.0$ as a standard of expansion is equivalent to assuming that the value of x_c is standard at about 0.65; however, no engineer would seriously propose that the value of x_c of 0.65 should be selected as a standard of economy. The elaborate theory of analysis built on the assumption that $n = 1.0$ is the natural result of the use of averages in any art where the actual facts have never been investigated.

The use of the equilateral hyperbola to predict the form of PV-diagrams for the purposes of design is satisfactory in the case of ordinary sizes of engines using saturated steam. When steam superheated over 100°F. is used, the value of n should be assumed at between 1.10 and 1.25. The high values of n obtained with highly superheated steam in large engines alter materially the division of work and the tangential forces acting from those obtained when n is assumed to be 1.0. This fact should be considered in the design of engines to use superheated steam. The use of the equilateral hyperbola to obtain the ratio known as the 'diagram factor' has no rational basis, but its use for this purpose gives results which are valuable for the purpose of design.

Mr. Clayton's conclusions as to the results obtained from the application of the logarithmic diagram to the analysis of cylinder performance are as follows:

1. The indicator diagram, taken by means of a correct reducing motion and with a reliable indicator, contains the evidence necessary for a complete and useful analysis of cylinder performance.

2. The logarithmic diagram, derived from the indicator diagram, discloses a new and complete analysis of cylinder performance.

3. Free from the influences of leakage, wrong clearance, wrong location of the line of zero pressure, and excessively low speed (principally in steam-engines), expansion or compression of an elastic medium takes place substantially according to the law $PV^n = C$.

4. The clearance of cylinders may be found by graphical trial on logarithmic cross-section paper to within 5 to 10% of the clearance volume, depending as the clearance itself varies from 20 to 2%, respectively, of the piston displacement.

5. The cyclic events, even though entirely obscure in the indicator diagram, may be located on the logarithmic diagram (when plotted on logarithmic paper of 5 in. per square) to within 1/16 in., this quantity being the equivalent of about 1/32 in. when transferred to the indicator diagram.

6. Leakage (if appreciable) may be reliably detected from the logarithmic diagram, and may, in some cases, be approximated in volume.

7. The weight of steam retained in compression should be obtained from the logarithmic diagram by prolonging the line of constant weight of steam mixture to the back-pressure line extended; the intersection of these two extended lines is the volume of steam which is retained.

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Concrete in Sewer Construction*

By W. J. BAIRD

THERE has been an idea prevalent for many years among the builders of sewers that concrete is inferior to sewer brick, in its power to resist the erosive action of sediment-carrying sewage. Just how this idea originated, and how much foundation for it there is in fact, is difficult to say. But the result of the belief has been that about two-thirds of the concrete sewers constructed have had their inverts lined with some supposedly harder material, such as vitrified tile plates.

In discussing the wear of sewer inverts G. S. Rankin instances the case of a brick sewer, 600 ft. long, which came under his observation in which the invert was completely worn through and had to be renewed at a considerable expense. He also quotes the following instances from Folwell's 'Sewerage.' "A 5½-ft. two-ring brick sewer in Baltimore, 25 years old, was recently found with its invert cut completely through for a width of 12 to 15 in. and badly worn to the height of 2 ft. In Omaha, brick sewers, the wear of which is usually 18 to 24 in. wide, became from 2 to 5 in. deep in 12 years."

In Newark, New Jersey, a brick sewer built in 1886, size 45 by 69 in., with a grade of 1.6%, was found to have its invert almost completely worn through in 1910. As a result of this wearing, it has been the custom to line the lower third or quarter of the cross-section with vitrified paving brick. The only test required was that the brick should not absorb more than 2% of its weight in water after being thoroughly dried, and immersed in water for 24 hours.

Experiments were made by Mr. Rankin with the idea of determining the relative wearing qualities of several materials and their consequent suitability as material for sewer inverts. The samples were first tested for absorption and then placed on a rubbing machine such as used in stone yards for rubbing blocks of stone. The samples were all 20 lb. in weight and were left on the machine 20 minutes, the velocity of the rubbing machine being at the rate of 22 ft. per second.

TABLE No. 1

No.	MATERIAL	% Gained by Absorp.	% Lost by Abras.	Ratio Absorp. to Abras.	Life of Invert in years	Remarks
1	Vitrified Shale Brick.....	1.36	2.00	1 : 1.47	324	The life of the invert in years is calculated by assuming the life of No. 8 as 10 years.
2	Vitrified Shale Brick.....	2.15	3.35	1 : 1.56	193	
3	Vitrified Shale Brick.....	3.60	3.42	1 : .95	189	
4	Vitrified Shale Brick.....	4.28	5.92	1 : 1.38	109	
5	Shale Sewer Brick.....	13.18	27.31	1 : 2.07	24	
6	Building Brick.....	7.39	20.41	1 : 2.76	31	
7	Building Brick.....	10.19	44.74	1 : 4.39	15	
8	Building Brick.....	18.91	64.74	1 : 3.42	10	
9	1 : 2 Cement Mortar....	11.86	4.41	1 : .37	147	
10	1 : 2 : 4 Grav. Concrete	6.65	3.82	1 : .57	169	
11	1 : 2 : 4 Grav. Concrete	5.10	3.35	1 : .66	193	
12	1 : 2 : 5 Stone Concrete	7.40	8.62	1 : 1.16	75	
13	Vitrified Tile.....	1.34	4.47	1 : 3.34	145	
14	Vitrified Pipe.....	4.47	6.11	1 : 1.37	109	
15	Vitrified Pipe.....	1.72	4.55	1 : 2.65	142	

The results of the experiment were as shown in the following table:

Specimens No. 1 to 4 were vitrified shale paving brick selected for their variation in absorption. No. 5 was a small shale brick

*Abstract from *Applied Science*, June 1912.

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made for use in sewers. No. 6, 7, and 8 were different makes of building brick, also selected for their variation in absorption. No. 9, 10, and 12 were made from the mortar and concrete being used in the construction of a sewer at the time of the experiment. No. 11 was a section of concrete pipe furnished by the Lock Joint Pipe Co., and was about one year old. No. 13 was a tile used by the same company for lining their pipes, when required by engineers. No. 14 and 15 were samples of salt-glazed vitrified pipe.

While admitting that these experiments are far from being complete and exhaustive, Mr. Rankin draws the following conclusions from them: (1) That for similar materials, although there is considerable variation in the ratio, the abrasion in every case except No. 12 increases with the absorption, that gives a fair idea of the wearing qualities of the materials; (2) the additional cost of lining a brick is warranted, although the 2% requirement of the Newark specifications seem unnecessarily severe; (3) the concrete sample compares favorably with paving brick and it would appear unnecessary to line a concrete sewer; (4) tile pipe is generally not as durable as concrete pipe.

The last two clauses are particularly noteworthy in connection with the subject under discussion, and are somewhat contrary to the belief commonly held by many people who cannot be accused of being prejudiced against concrete in any way. Tests by C. C. Clarke tend to indicate that the best proportion to resist abrasive forces are 1: 2 for portland cement mortar. This fact might be made use of in plastering the inside of concrete sewers, as is sometimes done. Mr. Hermann describes some investigations into the wearing power of some sewers in St. Louis. The grades of these sewers range from 0.2 to 2%. The vitrified clay pipes show no appreciable wear after 35 years use. These are usually laterals carrying small amounts of sewage, but carrying a considerable quantity of strong acids and scalding water. The vitrified brick sewers also show no appreciable wear, but they have been only about 12 years in use. One course of square-edged vitrified bricks are used for the bottom quarter of the circular sewers, and in those of other shapes are carried up six inches above the ordinary foul water flow.

In Duluth, Minnesota, the grades of the sewers are exceptionally steep, and it has been found impossible to keep sand and small stones out of the sewers. Concrete sewers have been proved to be more durable than brick. T. J. McGillivray, city engineer, says that he finds that the gravel and stones washed into the sewers in time of storms abrase the 'skin' of the vitrified clay sewer pipes, which results in the speedy disintegration of the pipe. In the construction of a sewerage system at Louisville, Kentucky, all sewers were lined when the size and grade were such that a velocity of 8 ft. per second would be likely to be exceeded. In small circular sewers of 24 to 36 in. diam. the lining was vitrified pipe, while in larger sewers the bottom and sides were lined with vitrified bricks laid in cement mortar. In view of the extra cost involved in the use of vitrified bricks and their doubtful efficacy, the use of vitrified brick lining for sewers appeasr to be doubtful economy.

There are two qualities which any material must possess before it can be successfully applied to sewer construction. These are water-tightness and smoothness of surface. Concrete is eminently fitted for sewers in that it is capable of being constructed with a very smooth surface, and all special construction necessitating the use of sharp angles and curves can be made perfectly true to shape, thus offering little resistance to the flow of sewage. This is of great advantage where there are many sharp turns in the sewer and the grade is slight.

In order that a sewer may fulfill the duties for which it was built, it must have such a form and be laid to such a grade as to cause a sufficient velocity in the water to carry along any solid materials that may be in the sewage. Upon reference to literature on hydraulics, we find that a velocity of water in a pipe of 2½ to 3 ft. per second is necessary in order to cause such materials as sand, gravel, etc., to be carried along. According to Ogden, in his work entitled 'Sewer Design,' if a pipe has these velocities in it when flowing half full, it will have a self-cleansing velocity when only flowing partly full. Suppose that it is decided, in designing a sewer, that a velocity of 3 ft. per second when the sewer is half full is the minimum allowable velocity. It is desired to find the minimum grade that will produce this velocity. For the sake of illustration the cross-section of the sewer shall be considered circular.

The formula most used in computing the

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velocity of water is Chezy's.

$$V = C\sqrt{RS}$$ where

V = velocity in feet per second.

R = hydraulic radius.

S = size of slope angle.

C = constant, depending on the slope, shape of cross-section, and roughness of surface. C is usually determined from Kutter's formula:

$$C = \frac{41.66 + \frac{1.811}{n} + \frac{.00281}{s}}{1 + (41.66 + \frac{00281}{s})\frac{n}{\sqrt{R}}}$$

where n is a coefficient of roughness, depending on the roughness of the surface with which the water is in contact, the other symbols having the same significance as in Chezy's formula. Before proceeding any further it is necessary to fix the value of n to be used in the above formula. Merriman gives the following values for n:

n = 0.011 for cement mortar, 0.013 for good brickwork, and 0.015 for unclean surfaces in sewers.

In Ogden's 'Sewer Design' the following values are given:

n = 0.011 for cement mortar and cement pipes well jointed and in good condition, 0.012 for tough cement mortar, and 0.013 for well laid brickwork.

In the design of the concrete sewers at Louisville, Kentucky, a coefficient of n = 0.013 was used. It would appear that for concrete sewers in fair condition a coefficient of n = 0.012 would be reasonable, while in brickwork a value of n = 0.015 would be all that could be expected. This difference in the values of the coefficients will have the effect of producing different results in determining the minimum grades in order to produce the minimum velocity in the two different types of sewers.

In a case where the outlet has to be kept as high as possible while preserving a minimum grade in the sewer, a considerable saving in excavation might be effected by using a concrete sewer in preference to a brick one. Thus, for a 5-ft. sewer the saving in grade would be 0.023 ft. per 100 ft. This in a mile of sewer would mean a saving in excavation at the end of the mile of 1.12 ft. The saving in the cost of a mile of excavation in rock would be (taking the cost of rock excavation as being $3 per cubic yard) approximately $1900. This in a sewer several miles long would effect a considerable saving. For earth excavation, however, the saving would probably be not more than one-sixth of this amount. Also in low level sewers where the sewage has been pumped, a reduction of the grade would mean a reduction in the height which the sewage has to be raised.

The difference in roughness of the interior surface of the two different types of sewer results also in a difference in their carrying capacity. This is shown very clearly by accompanying curves. These show that for any particular diameter of pipe and grade, the concrete sewer has a much greater carrying capacity than the brick sewer. Although the cases here illustrated are very limited in their application, the sewers being supposed of circular cross-section and to be flowing full, the fact remains that concrete

TABLE No. 2

DIAMETER OF PIPE IN FEET	MINIMUM GRADE	
	CONCRETE n = .012	BRICK n = 015
2	.00150	.00260
3	.00085	.00140
4	.00055	.00092
5	.00042	.00065
6	.00034	.00053
7	.00027	.00043
8	.00022	.00037
10	.00017	.000275

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sewers have a greater carrying capacity than brick sewers of the same size whatever be the shape of the cross-section, or the condition of flow in the sewer. Some may not agree that there is as great difference as is found by using values of $n = 0.012$ and $n = 0.015$ for concrete and brick sewers respectively, but it is quite apparent that a higher value would be used for brick than for concrete sewers, and the values above mentioned are about as good as can be obtained at this stage of our knowledge of the flow of water in pipes. In the foregoing computations the usual assumption has been made, that, so far as the hydraulics of the case are concerned, sewage is practically all water.

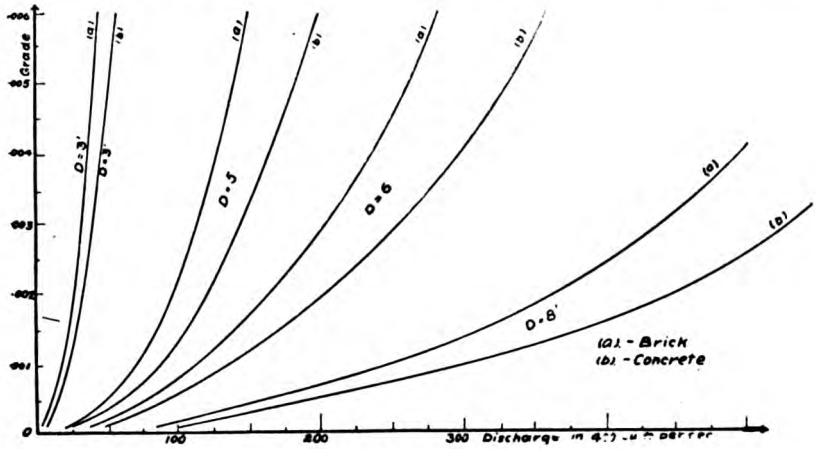

FIG. 1.

It has been frequently asserted that concrete not being an absolutely water-proof material in itself, concrete sewers would be defective in that they would be liable to admit ground water and also allow the sewage to leak out, thus polluting the ground in the vicinity of the sewer. This is, apparently, erroneous, when one considers that there are numerous concrete pipe-lines all over the country which convey water, sometimes under considerable heads, without undue leakage. This would seem to indicate that it is perfectly possible to make concrete waterproof.

The first essential of a waterproof sewer is a carefully graded and mixed concrete. A careful study of the aggregate to be used should be made and an effort should be made to have as dense a mixture of concrete as it is possible to obtain. Also, especial care should be taken in the mixing, placing, and bonding of the concrete. If this is done an important step toward obtaining a waterproof sewer has been taken. Lime and fine clay have sometimes been used in waterproofing concrete sewers.

Preliminary to the construction of the Louisville sewerage system the commission in charge made some tests for finding the most impervious concrete. Concrete pipes were tested for about seven hours under a pressure of about 15 lb. per square inch. The concrete used consisted of one part of cement to two parts of Ohio river sand to four parts of Ohio river gravel. Tests were made on plain concrete and on concrete containing lime, clay, and various percentages of several waterproofing compounds. The best results were obtained by the use of 4% Medusa and 4% Toxement waterproofing compounds, the seepage in each case being zero. With the 1: 2: 4 concrete the seepage was 6.30 cu. in. per square inch of surface. In a part of the construction of these same sewers a fine clayey molding sand was used for 10% of the sand 1: 2: 4 mix. The sand was thoroughly mixed with water and then mixed with the rest of the sand and the cement. As far as can be seen this method is satisfactory. So far as the permeability of concrete sewers and their consequent liability to leakage is concerned, there seems to be little cause for alarm, provided reasonable care is used in the construction.

In designing sewers it is usually customary to consider the sewer as having to sustain

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all the dead load of the fill over it and also all the live load that is likely to come on it when the amount of cover is less than 4 ft. When the amount of fill exceeds 4 ft. the sewer is supposed to be capable of sustaining the weight of the fill and a certain percentage of the live load, this percentage varying from 100 at 4 ft. deep to zero at about 14 ft., at which point the live load is supposed to cease to have any effect. These figures are only assumptions, although probably very reasonable ones, since it is difficult to arrive at any definite conclusions from theoretical considerations alone, owing to the uncertain nature of earth pressures.

An empirical formula for determining the amount of pressure liable to come on the sewer from the dead and live loads runs as follows:

$$\text{Dead load} = 83d - 2.54d^2$$

$$\text{Live load} = 1000 + 3.72d^2 - 112d$$

where d = depth of fill over sewer.

According to this formula the live load ceases to have any effect when the depth of fill exceeds about 15 feet.

In designing sewers considerable allowance has to be made for the uncertain stresses liable to be set up by irregular settlements of the foundations, and quite large factors of safety are usually considered necessary. A complete analysis of the subject of stresses in circular sewers and culverts subjected to earth pressure is given by A. N. Talbot in a bulletin issued by the University of Illinois. In introducing the subject, Mr. Talbot says: "The stresses developed in rings and pipes subject to external pressure, are, of course, dependent upon the bending moments developed. As the exact load coming on the sewer and its distribution over the surface are difficult to determine, the bending moment is in general quite uncertain. The amount of load and its distribution over the surface, and therefore the bending moment on different parts of the ring depend upon a number of conditions, such as the nature of the earth used in filling, the method of bedding the pipe, the manner of tamping the earth at the side, the amount of lateral restraint or pressure of the earth, the conditions regarding moisture, etc." These conditions of loading may include: (1) a concentrated load at the crown; (2) a vertical load distributed uniformly over the horizontal section; (3) a distributed vertical load together with a horizontal load distributed perpendicularly over the sides of the ring; (4) an oblique load, such as may prevail in a sewer trench, a slip of earth causing pressures to be set up in the sewer that are not provided for in any of the previous cases.

Mr. Talbot made a large number of tests on plain and reinforced concrete rings and pipes, comparing the results of these tests with those derived from formulae. An examination of his results shows the chief benefits to be derived from the reinforcing of concrete pipes would be in lessening the liability of sudden failure from shock and pressures not otherwise provided for, and in permitting the use of thinner shell for the pipe. The reinforcement should also be taken into account in fixing on a proper factor of safety. The main lesson to be derived from his tests is, however, the advisability of providing a uniform bedding for the sewer and an evenly distributed, well-compacted filling, in order that the pressures on the sewer may be distributed and not concentrated.

So far as the small number of tests made upon the relative strength of concrete and vitrified clay pipes admits of a conclusion the resistance of the pipes against outside compression varies to a great extent, even with pipes of the same size, and made of the same materials. However, the concrete pipes seem to give slightly higher average values than vitrified clay pipes.

Tile pipe is now made in various sizes up to 42 in. diam., but the concensus of opinion among engineers seems to be that their use is inadvisable when a sewer of greater diameter than 20 in. is required. The ability to use steel reinforcement, either in pipes or monolithic construction, to take up the tensile stresses, would seem to be an important point in favor of the use of concrete for sizes of greater diameter than 20 inches.

In the construction of sewers in Richmond, Indiana, vitrified tile pipe was used for sizes up to and including 18 in. diam., while concrete was used for sewers of from 20 to 54 in. diameter. The 20-in. pipe was not reinforced and was found to be unsatisfactory; the larger sizes were reinforced and gave good satisfaction. The strength of the plain concrete pipes of small diameter does not seem to be much different from that of tile pipes of the same diameter, while for the larger sizes good design and proper construction is

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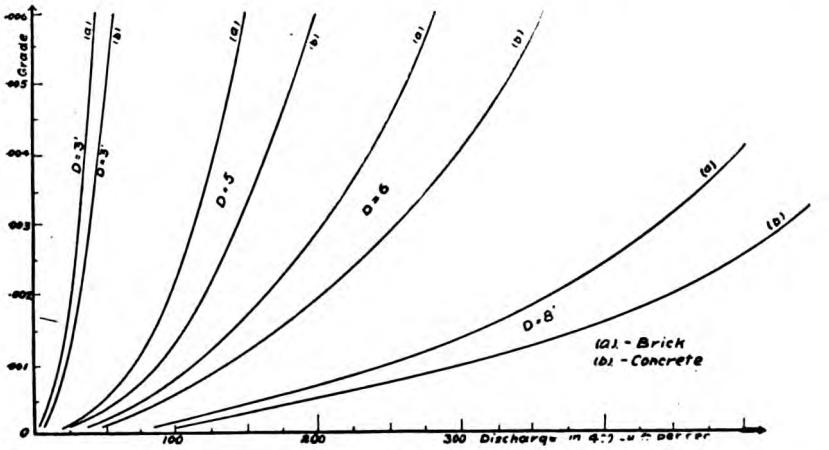

FIG. 1.

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The first essential of a waterproof sewer is a carefully graded and mixed concrete. A careful study of the aggregate to be used should be made and an effort should be made to have as dense a mixture of concrete as it is possible to obtain. Also, especial care should be taken in the mixing, placing, and bonding of the concrete. If this is done an important step toward obtaining a waterproof sewer has been taken. Lime and fine clay have sometimes been used in waterproofing concrete sewers.

Preliminary to the construction of the Louisville sewerage system the commission in charge made some tests for finding the most impervious concrete. Concrete pipes were tested for about seven hours under a pressure of about 15 lb. per square inch. The concrete used consisted of one part of cement to two parts of Ohio river sand to four parts of Ohio river gravel. Tests were made on plain concrete and on concrete containing lime, clay, and various percentages of several waterproofing compounds. The best results were obtained by the use of 4% Medusa and 4% Toxement waterproofing compounds, the seepage in each case being zero. With the 1: 2: 4 concrete the seepage was 6.30 cu. in. per square inch of surface. In a part of the construction of these same sewers a fine clayey molding sand was used for 10% of the sand 1: 2: 4 mix. The sand was thoroughly mixed with water and then mixed with the rest of the sand and the cement. As far as can be seen this method is satisfactory. So far as the permeability of concrete sewers and their consequent liability to leakage is concerned, there seems to be little cause for alarm, provided reasonable care is used in the construction.

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all the dead load of the fill over it and also all the live load that is likely to come on it when the amount of cover is less than 4 ft. When the amount of fill exceeds 4 ft. the sewer is supposed to be capable of sustaining the weight of the fill and a certain percentage of the live load, this percentage varying from 100 at 4 ft. deep to zero at about 14 ft., at which point the live load is supposed to cease to have any effect. These figures are only assumptions, although probably very reasonable ones, since it is difficult to arrive at any definite conclusions from theoretical considerations alone, owing to the uncertain nature of earth pressures.

An empirical formula for determining the amount of pressure liable to come on the sewer from the dead and live loads runs as follows:

$$\text{Dead load} = 83d - 2.54d^2$$

$$\text{Live load} = 1000 + 3.72d^2 - 112d$$

where d = depth of fill over sewer.

According to this formula the live load ceases to have any effect when the depth of fill exceeds about 15 feet.

In designing sewers considerable allowance has to be made for the uncertain stresses liable to be set up by irregular settlements of the foundations, and quite large factors of safety are usually considered necessary. A complete analysis of the subject of stresses in circular sewers and culverts subjected to earth pressure is given by A. N. Talbot in a bulletin issued by the University of Illinois. In introducing the subject, Mr. Talbot says: "The stresses developed in rings and pipes subject to external pressure, are, of course, dependent upon the bending moments developed. As the exact load coming on the sewer and its distribution over the surface are difficult to determine, the bending moment is in general quite uncertain. The amount of load and its distribution over the surface, and therefore the bending moment on different parts of the ring depend upon a number of conditions, such as the nature of the earth used in filling, the method of bedding the pipe, the manner of tamping the earth at the side, the amount of lateral restraint or pressure of the earth, the conditions regarding moisture, etc." These conditions of loading may include: (1) a concentrated load at the crown; (2) a vertical load distributed uniformly over the horizontal section; (3) a distributed vertical load together with a horizontal load distributed perpendicularly over the sides of the ring; (4) an oblique load, such as may prevail in a sewer trench, a slip of earth causing pressures to be set up in the sewer that are not provided for in any of the previous cases.

Mr. Talbot made a large number of tests on plain and reinforced concrete rings and pipes, comparing the results of these tests with those derived from formulae. An examination of his results shows the chief benefits to be derived from the reinforcing of concrete pipes would be in lessening the liability of sudden failure from shock and pressures not otherwise provided for, and in permitting the use of thinner shell for the pipe. The reinforcement should also be taken into account in fixing on a proper factor of safety. The main lesson to be derived from his tests is, however, the advisability of providing a uniform bedding for the sewer and an evenly distributed, well-compacted filling, in order that the pressures on the sewer may be distributed and not concentrated.

So far as the small number of tests made upon the relative strength of concrete and vitrified clay pipes admits of a conclusion the resistance of the pipes against outside compression varies to a great extent, even with pipes of the same size, and made of the same materials. However, the concrete pipes seem to give slightly higher average values than vitrified clay pipes.

Tile pipe is now made in various sizes up to 42 in. diam., but the concensus of opinion among engineers seems to be that their use is inadvisable when a sewer of greater diameter than 20 in. is required. The ability to use steel reinforcement, either in pipes or monolithic construction, to take up the tensile stresses, would seem to be an important point in favor of the use of concrete for sizes of greater diameter than 20 inches.

In the construction of sewers in Richmond, Indiana, vitrified tile pipe was used for sizes up to and including 18 in. diam., while concrete was used for sewers of from 20 to 54 in. diameter. The 20-in. pipe was not reinforced and was found to be unsatisfactory; the larger sizes were reinforced and gave good satisfaction. The strength of the plain concrete pipes of small diameter does not seem to be much different from that of tile pipes of the same diameter, while for the larger sizes good design and proper construction is

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all that is required in order to obtain a thoroughly strong and reliable concrete sewer.

The relative costs of sewers of different materials in any particular case, depends largely on circumstances peculiar to that case, such as the proximity to the source of manufacture. However, there are several general principles which hold true in almost all circumstances, and are applicable to a greater or less extent under all conditions, which tend to make concrete sewers cheaper than brick ones of the same size. Within the past few years the price of brick has advanced about 50%, while the price of cement has decreased about the same amount. The market price of broken stone and sand, while governed almost entirely by local conditions, has remained nearly constant. About 75% of the weight of the entire masonry of brick sewers, that is, the bricks themselves, must be transported from the factory to the site of the work. A large cost is usually involved in freight and teaming charges. On the other hand, in the case of a concrete sewer, frequently about 10% of the weight, namely, the cement, has to be brought long distances, and since the quantity required is only slightly in excess of that required for brick masonry, the gain is still more apparent. The high cost of vitrified brick also tends to increase the cost of masonry structures. Only skilled bricklayers can lay bricks for sewers, and skilled labor is expensive, while concrete can be laid by unskilled laborers. Bricklayers have powerful unions, and a contractor is liable to be held up by a strike among his bricklayers, the possibility of which he has to allow for in his bid.

A brick wall must be built of sufficent thickness to contain the line of pressure near the middle third of the ring, in order to prevent cracking. This generally results in working the materials at a low efficiency. For example, masonry that can safely withstand a pressure of from 1000 to 2000 lb. per square inch is worked at a pressure rarely exceeding 300 lb. per square inch, as to increase the unit pressure would produce rupture in the part of the arch subjected to tension. Concrete has the advantage that it can be reinforced with steel. With steel reinforcement, the mass of the masonry may be cut down 50% and the materials comprising the structure may be worked at predetermined and properly ascertained efficiencies.

TABLE No. 3

Diam. of sewer in ft.	Length in ft.	Concrete Block Construction				Prices Bid Per Lineal Foot				
		Thickness in.	Vol. in cu. ft. p.l.f.	Transverse steel		Concrete Blocks	Monolithic Concrete		Brick	
				Size of rods	lbs. Total					
72	4342	5	8.4	9–16″	18.2	$17.70	8	$13.00	13	$12.75
66	2642	4½	7.0	7–16″	13.8	8.50	7	11.00	9	9.10
52	965	4	5.0	7–16″	10.5	6.25	6	7.00	9	6.85
48	980	4	4.76	3–8″	6.8	6.00	6	7.00	9	6.36
42	359	3½	3.65	3–8″	6.0	4.50	5½	6.00	9	5.76
36	321	3	2.68	3–8″	5.3	4.00	5½	6.00	9	5.00
30	714	2½	1.86	3–8″	4.5	3.00	4½	4.00	9	3.70
24	827	2½	1.50	5–16″	2.5	2.10	3½	2.50	9	2.20

As shown before, a concrete sewer will carry a much greater volume of sewage than a brick sewer of the same size, laid on the same grade. Thus, when a given amount of sewage is to be carried, a smaller sized concrete sewer will suffice than would be required for a brick sewer. A concrete sewer 6 ft. diam. has nearly as great a carrying capacity as a brick sewer 6½ ft. diam. Supposing in the two cases, the factors of thickness of the wall of the sewer, the cost of the material in each case to be the same, then the increased diameter will be responsible for an increase in the amount, and consequently in the cost of the material, of about 5%, and for an increase in the amount of excavation necessary of about 7 per cent.

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From the above theoretical consideration it would be supposed that brick sewers would be more expensive than concrete ones of the same carrying capacity. Upon examining cases where bids have been received for the construction of a sewer of concrete or brick, we find that the truth of these assumptions is borne out by practice. A notable instance of this is a concrete sewer constructed at Toledo, Ohio. Bids were called for a sewer to be either of brick, concrete block, monolithic concrete, or reinforced concrete construction. The contract was awarded to Breymann & O'Neil, of Toledo, on block construction according to the designs and patents of W. C. Parmeley. The prices for each section of the sewer and for each different type of construction were as shown in the accompanying table, being the lowest one for each of the types. No bids were received for a reinforced-concrete sewer.

In the construction of the high-level intercepting sewer in Toronto, certain sections of it were built on concrete lined with brick, and others of brick alone. In the sections where concrete was used the economy was very marked, as shown by the bids received for the two different types of construction. For instance, in section No. 3 (Jarvis street to the Don) the lowest bid received for a brick sewer was $33.13 per lineal foot, while for a concrete sewer the lowest bid was $19.97 per lineal foot. By the use of concrete alone, a saving of $84,500 would have been effected in this section. As it was, brick-lined concrete was used at a saving of $72,000 compared to the cost of a similar brick sewer.

The cost of concrete pipes varies greatly under differing conditions, but in general they are cheaper than vitrified-tile pipes of the same size. At Denver, Colorado, 7000 ft. of 38-in. continuous concrete pipe was made by the Ransome process. The cost of the pipe was $1.35 to $1.50 per foot, with cement at $3.75 per bbl., gravel $1.25 per yd., and wages $1.75 to $2 per day. The cost of the same size vitrified pipe would have been about $3 per foot in place. In 1894 at Scarborough-on-the-Hudson, 900 ft. of 24-in. pipe and a mile of 10-in. pipe were built by the Chenoweth process at a cost of 95c. per foot for the larger size and 23c. for the smaller, as compared with 97c. and 30c. for the corresponding sizes of vitrified tile. At Despatch, New York, concrete pipe made by the continuous process cost as follows: for 8-in. pipe, about $0.063 per lineal foot, 300 ft. being constructed per day; for 12-in. pipe, $0.1025 per foot, about 400 ft. being constructed per day. Vitrified pipe, under the same circumstances, would have cost $0.175 for the 8-in. and $0.35 per foot for the 12-in. pipe. As can be noted, these prices for the tile pipe are lower than can usually be obtained in most places.

In general, concrete sewers seem to be cheaper than those of other materials, in many cases by a considerable amount, and very seldom, if ever, are they more expensive than those of brick or vitrified tile construction.

TABLE NO. 4

Size inches	Thickness, in.	Cubic Feet of Sand per Pipe	Cost of Labor	Total Cost Per Foot
6	1	.324	$0.08	$0.050
8	1	.452	0.08	0.065
10	1⅜	.830	0.10	0.115
12	1½	1.100	0.10	0.155
15	1½	1.400	0.11	0.192
18	1⅝	1.840	0.13	0.237
20	1¾	1.950	0.13	0.255
24	2	2.750	0.15	0.343
30	2½	3.700	0.17	0.443
36	3	4.900	0.20	0.575

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The Internal-Combustion Engine*

THE development of large gas-engine units has gone steadily forward for the past decade. The first engine of this class was that exhibited by the John Cockerel company at the Paris Exposition in 1900. This was an engine of 600-hp. rating. At the present time 1500 hp. in each cylinder of the four-stroke cycle type and 2000 hp. in each cylinder of the 2-stroke cycle engine are reported as ratings of exhibits at the recent exposition at Brussels. This means units of 8000 hp. of the twin-tandem, double-acting type.

It is understood that at least one company is prepared to install gas-engine plants of large power capacity at a cost not exceeding and in some instances less than that of the corresponding steam-turbine installations.

Although the steam turbine has superseded the reciprocating steam-engine for the generation of electricity in central-station work, and will probably hold the field for some time to come, it is interesting to note that the Diesel engine, owing to its great success in small station work, is looked upon seriously as a proximate possible rival to the steam turbine. In a paper recently presented before the Municipal Electrical Association at Brighton, England, the relative cost of a 10,000-kw. installation for steam turbines, gas producers and engines, and Diesel engines, was discussed at length. The author proposed the use of seven sets, each of 1450-kw. capacity. His figures of operating expense, etc., are decidedly in favor of the Diesel engine installation.

Attention was also called to the very economical use of these engines as a substitute for sub-station converting machinery. Such stations are already appearing in London.

In this connection, the increase in the size of the Diesel engine is worthy of note. Engines of a few hundred horse-power have become common in Europe. In Swiss electric stations Diesel-engine units of 2000 hp. are now in use, and one writer states that the development of the large-sized Diesel engine has been so successful that it will not be long before 1000 hp. developed in one cylinder will be deemed nothing extraordinary. One company of world-wide reputation is at present considering more than 2000 hp. in the single-cylinder type of Diesel engines. It is stated that engines of this type with four cylinders, developing 100 hp. each, can be made as light as the corresponding triple-expansion steam-engine.

The weight of such engines compares favorably with that of the corresponding turbines and boilers. It is understood that a 1000-hp. installation of this type weighed only 187 lb. per horse-power as compared with 180 lb. for a steam turbine and boiler installation.

The crude-oil engine is now definitely under consideration for all types of marine craft. For small vessels the advantage lies in the safety afforded by the use of crude oil as compared with lighter oils. The crude-oil engine is being used by many of the principal navies of the world for submarine boats, and designs are already under way for comparatively large engines for torpedo-boats and other similar craft.

A few months ago the *Vulcanus*, a vessel of 1900 tons displacement, 196 ft. long, equipped with 6-cylinder, 4-cycle, single-acting reversible Diesel engines, was put in regular service between Holland and Borneo. This engine is about 500-b.hp. capacity at 180 r.p.m. The fuel is a crude oil from Borneo, and the quoted guaranties are 0.42 lb. per b.hp-hr. at full speed; 0.44 lb. at three-quarters speed; and 0.5 lb. at half speed. In a recent trip the *Vulcanus* covered 3312 miles in 19 days and 3 hours. The average speeds varied from 6.86 to 7.80 knots. It is reported that the average consumption for this ship amounts to one ton of fuel oil per 100 knots.

The technical journals of recent date record many such installations. Among these Russia is credited with at least four freight vessels of 1000 hp. and two 14-knot gunboats of the same horse-power rating. In December 1911 two vessels, nearly 400 ft. long and of 7000 tons capacity, each fitted with Diesel engines of 2500-hp. rating and with two auxiliary Diesel engines aggregating 500 hp., were being tried out in European waters.

The attention of marine engineers is espe-

*From an address before the gas-power section of the American Society of Mechanical Engineers, New York, December 1911. Also printed as Technical Paper No. 9, U. S. Bureau of Mines.

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cially directed to the most recent development in the oil-engine field—the Junkers oil engine. These engines for the freight vessels of the Hamburg-American Line are of the twin-tandem type of 1600 total shaft horse-power each. The engines operate on the 2-cycle principle, and through the introduction of two pistons into each cylinder, double action is obtained.

An interesting comparison will shortly be placed before the public by the British Admiralty, which proposes to try out side by side in a twin-screw cruiser a steam-engine and a Diesel engine of 6000-hp. rating. A destroyer recently ordered by the British Admiralty, according to current reports, will have on each shaft a steam turbine and a Diesel engine. The plan is to operate the turbines when high speeds are required; but under cruising conditions, when the speeds are low, owing to the poor economy of the steam turbines, the Diesel engines will be used. The combined economy from this arrangement will be exceedingly interesting. One of the interesting features of engine development is the fact that there seems to be a marked tendency toward the 2-stroke cycle for marine work.

With the introduction of internal-combustion engines the discomforts of the stokehole will be greatly reduced, the labor required will be less than under present marine conditions, and the character of the labor will be much improved. Although steam-engines probably will not be rapidly displaced in the larger ocean-going craft, yet the crude-oil engine seems to be especially adapted for such service as that previously indicated. The quantity of fuel needed approximates a third of that needed for the steam-engine, hence the radius of action for a given weight of fuel is greatly increased. Boilers can be eliminated and their space utilized for carrying cargo. It is reported that in the case of a freight vessel of 2700 tons burden, a saving of over $19 per day was made by using oil at approximately $11 per ton instead of coal at about $3 per ton.

Tar oil has become a more or less common fuel for Diesel engines of 600 or 800-hp. rating, and it is understood that tar is used in at least one engine of 4000-hp. rating. Recent experiments indicate that both thin gas-retort tar and thick coke-oven tar can be used by injecting into the cylinder a small percentage of light oil to assist in igniting the tar. It is claimed that a wide range of tars can be used in this manner without producing smoke or appreciable residue. In tests at the Körting Works about 2% of the ignition oil was added at full load and about 13% at half load. Reports indicate that an order has been placed for a 600-hp. Diesel engine to operate with raw tar.

Locomotives using internal-combustion engines and operating on tracks of standard gauge have been recently put into service. The range of fuel for these engines covers gasoline, benzol, alcohol, and petroleum. The Prussian state railways are reported to be operating a 1000-hp. locomotive using a Diesel engine as motive power.

Results are soon to be expected from the more recent investigations and tests relating to gas turbines. Some of the types are believed to be based on correct principles, so that after a satisfactory rotary air-compressor has been designed, rapid progress in the development of this prime mover may be expected.

Not only do the renewed and increased orders for internal-combustion engines by the great manufacturing corporations indicate a feeling of assured reliability, but the subsidizing by European war departments of petrol-motor lorries indicates a feeling of reliability in the internal-combustion principle that is beyond dispute. These vehicles will be held subject to purchase in case of need by the war departments. An important stipulation is: "The engines must be of the internal-combustion type using petrol, and by preference having four cylinders."

The Humphrey internal-combustion pump has been before the public for two or three years. The 1000-hp. pump occupies about the same space as the tandem double-acting gas-engine of the same power. Many similar internal-combustion pumps are clamoring for admission to the field. The comptroller of the British patent office, in discussing the validity of the Humphrey patents, states: "The Humphrey pumps show an important advance in the art. Although many applications have been filed for patents since 1858, none has embodied the principles of the Humphrey pump."[1]

Various methods of utilizing the waste

[1] *Engineering* (London), Vol. 92, Sept. 1, 1911, p. 295.

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heat of the gas-engine exhaust have been attempted from time to time, and the demand for such devices for heating buildings has been large. Several schemes for accomplishing this result are now commercially in use, but according to recent opinion the most efficient method of utilizing the exhaust is through a combination of gas and steam-engines.

Present practice indicates that about 3 lb. of steam is generated per brake-horsepower-hour by means of boilers heated by the exhaust. According to A. E. L. Chorlton, the use of exhaust boilers with efficient steam-engines and specially designed gas-engines of the 2-cycle type will effect marked thermal economics and reduce the initial cost per horse-power of the installation.[2]

One of the technical journals[3] states that Mr. Chorlton shows by numerical examples the possibilities of such an engine, first examining the case of the addition of a steam end to a normal economical gas-engine. He assumes a standard engine to use 9500 b.t.u. per b.hp.-hour. As the engine is ordinarily arranged with jacket feed to the boilers, one may take 40% of this heat to be recoverable. From this, at 80% efficiency of conversion at 100 lb. pressure, there would be recovered about 2½ lb. of steam per b.hp.-hour. This amount of steam in an ordinary simple steam-engine would not give more than 10 to 12% of the main engine power, a return that hardly justifies the first cost of the steam cylinder. Consequently no development has taken place in this direction.

When, however, one deals with a special combined compound engine, each part of which is made in the way most suitable for the purpose required, one gets a very different result. In order to reduce the cost of the gas-engine part, the compression would be lowered, and with the ignition retarded, a much lower maximum pressure and temperature would result; the total heat units used would go up to about 12,000 b.t.u., but more would be rejected to the exhaust, and with a special arrangement of boiler, economizer pipes, and superheaters in exhaust, 50% of the waste should be recoverable. There should be obtained from this 4 lb. of steam per brake-horsepower-hour.

The steam cylinder used would be similar in type to that of the 2-cycle engine; that is, with no exhaust valves. The unidirectional-flow engine of this type has been largely reintroduced in Germany with very economical results. The jacketing of the ends could be done by exhaust gas. For small engines of this type it is safe to assume a steam consumption of 12 lb. per b.hp.-hour; a consumption of 10 lb. has been obtained in actual practice. Hence the power obtained from the steam cylinder would be one-third of that of the gas cylinder, and the consumption for total effective power would be reduced to 900 b.t.u. per b.hp-hr., or less than that for the economical gas-engine alone.

It is gratifying to note that each year gives evidence of the absurdity of many of the prophecies regarding the elimination of practically all prime-movers save the internal-combustion engine, and that the past year may be regarded as one of steady, conservative progress and development in this field. The opportunity for investigation in the gas-power fields is at present unlimited, and nearly a hundred important gas-power problems are at present on file at the Bureau of Mines under the head of 'Proposed Investigations."

Incomes of Engineers

IOWA STATE COLLEGE, Division of Engineers, has recently published a directory of graduates, containing interesting statistical information concerning the earnings of their engineering graduates. Some difficulty was experienced in obtaining replies to the blanks sent out, and only 55.3% of the total number of alumni responded. The results that were obtained, however, would indicate that a graduate may reasonably expect to receive from $50 to $75 per month as his first salary. The apprentice-

[2] *Engineering* (London), Vol. 90, Nov. 18, 1910, pp. 714-718; *Eng. Mag.*, Vol. 40, p. 607.

[3] *Eng. Mag.*, Vol. 41, May 1911, p. 311 (Abstract of paper before Manchester Assoc. Eng., Feb. 25, 1911.

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ship courses, which are proving of such inestimable value, tend to pull the average down considerably below what would probably be received if the graduate entered professional work at once, but it was a noticeable fact that the men who have taken such courses are the ones who are receiving the most rapid advances in salary, and are invariably working into positions of responsibility. The average salary of the class of 1910 was $1042 per annum seven months after graudation, an increase of 23.16% in that length of time. Average present incomes for the entire engineering division show a fairly uniform increase for fifteen years, after which it becomes more or less irregular on account of the small number of graduates, and the correspondingly small number of reports received. Maximum incomes run into five figures after fourteen years, and also show that some men attain incomes of from $4000 to $9000 within a comparatively few years. Had well founded assumptions as to incomes of some of the older graduates been included, many more large amounts could have been shown, but nothing has been included except as actually reported.

The class of 1891 deserves special mention. Reports as to the incomes were received from nine out of the fourteen graduates, and the average stands at $12,300. It is particularly striking that statistical reports of this nature from some of the other institutions show a corresponding abnormal average for graduates of the same year. Here, also, the figure is amply safe, as some who did not report salaries are highly successful business and professional men.

A comparison of the average present incomes of graduates of the different departments with that shown for the entire division shows that there is no great difference in the earning capacity of those engaged in the four branches of engineering.

The average of all incomes reported would indicate that the average engineering graduate may reasonably expect to receive an income of $2000 eight years after graduation, $3000 fifteen years after graduation, $4000 twenty-two years after graduation, and $5000 twenty-eight years after graduation. After twenty-five years the reports were not sufficiently complete to be very satisfactory. Probably, if accurate data could be obtained, the average would begin to drop again somewhere in the neighborhood of the thirtieth year.

Table of Conversion Factors*

By CARL HERING

A FLOW or radiation of heat may be measured in watts, in gram calories per second, or in ergs per second. In this table the term 'c.g.s. unit,' that is, the absolute unit, refers to the true ones based on the erg per second; those often called 'c.g.s. units' and based on the gram calorie are here given under the latter term. The centigrade degree is understood to be meant in all these units.

Thermal Resistance.

Thermal ohms:

= centigrade degrees ÷ watts = degrees per watt.

= 1 ÷ thermal mhos.

1 thermal ohm:

= a resistance requiring 1°C. per watt of flow.

= 4.18617 gram calorie units; approx. 50/12.

= 0.0000001 c.g.s. unit of thermal resistance.

1 gram calorie unit:

= a resistance requiring 1°C. per flow of a gram calorie per second.

= 0.238882 thermal ohms; approx. 24/100.

= 2.38882×10^{-8} c.g.s. units of thermal resistance.

1 c.g.s unit of thermal resistance:

= a resistance requiring 1°C. per flow of an erg per second.

= 10,000,000 thermal ohms.

*From an article on 'Simplification of Electro-Thermal Calculations; the Watt and Thermal Ohm,' *Proc.* A. I. E. E., June 1912.

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= 41,861,700 gram calorie units.

Thermal Conductance.

Thermal mhos:

= watts ÷ centigrade degrees = watts per degree.

= 1 ÷ thermal ohms.

1 thermal mho:

= a conductance permitting a flow of 1 watt per degree.

= 0.238882 gram calorie unit; approx. 24/100.

= 10,000,000 c.g.s. units of thermal conductance.

1 gram calorie unit:

= a conductance permitting a flow of 1 gram calorie per second per degree.

= 4.18617 thermal mhos; approx. 50/12.

= 41,861,700 c.g.s. units of thermal conductance.

1 c.g.s. unit of thermal conductance:

= a conductance permitting a flow of 1 erg per second per degree.

= 0.0000001 thermal mho.

= 2.38882×10^{-8} gram calorie units.

Thermal Resistivities.

(These are the reciprocals of the corresponding conductivity units.)

1 gram calorie, centimetre cube unit:

= 0.393700 gram calorie, inch cube, unit; approx. 4/10.

= 0.238882 thermal ohm, centimetre cube unit; approx. 24/100.

= 0.0940478 thermal ohm, inch cube, unit; approx. 2/21.

= 2.38882×10^{-8} c.g.s. units resistivity.

1 gram calorie, inch cube unit:

= 2.54001 gram calorie, centimetre cube units; approx. 10/4.

= 0.606762 thermal ohm, centimetre cube unit; approx. 3/5.

= 0.238882 thermal ohm, inch cube unit; approx. 24/100.

= 6.06762×10^{-8} c.g.s. units of resistivity.

1 thermal ohm, centimetre cube unit:

= 4.18617 gram calorie, centimetre cube units; approx. 50/12.

= 1.64809 gram calorie, inch cube units; approx. 5/3.

= 0.393700 thermal ohm, inch cube units; approx. 4/10.

= 10^{-7} c.g.s. units of resistivity.

1 thermal ohm, inch cube unit:

= 10.6329 gram calorie, centimetre cube units; approx. 21/2.

= 4.18617 gram calorie, inch cube units; approx. 50/12.

= 2.54001 thermal ohm, centimetre cube units; approx. 10/4.

= 2.54001×10^{-7} c.g.s. units of resistivity.

1 c.g.s. unit of resistivity:

= 418617×10^{7} gram calorie, centimetre cube, units.

= 1.64809×10^{7} gram calorie, inch cube units.

= 10^{7} thermal ohm, centimetre cube units.

= 3.93700×10^{6} thermal ohm, inch cube units.

Thermal Conductivities.

(These are the reciprocals of the corresponding restivity units.)

1 c.g.s. unit of conductivity:

= 2.54001×10^{-7} thermal mho, inch cube unit.

= 10^{-7} thermal mho, centimetre cube unit.

= 6.06762×10^{-8} gram calorie, inch cube unit.

= 2.38882×10^{-8} gram calorie, centimetre cube unit.

1 thermal mho, inch cube unit:

= 3.93700×10^{6} c.g.s. units of conductivity.

= 0.393700 thermal mho, centimetre cube unit; approx. 4/10.

= 0.228882 gram calorie, inch cube unit; approx. 24/100.

= 0.0940478 gram calorie, centimetre cube unit; approx. 2/21.

1 thermal mho, centimetre cube unit:

= 10^{7} c.g.s. units of conductivity.

= 2.54001 thermal mho, inch cube units; approx. 10/4.

= 0.606762 gram calorie, inch cube unit; approx. 3/5.

= 0.238882 gram calorie, centimetre cube unit; approx. 24/100.

1 gram calorie, inch cube unit:

= 1.64809×10^{7} c.g.s. units of conductivity.

= 4.18617 thermal mho, inch cube units; approx. 50/12.

= 1.64809 thermal mho, centimetre cube units; approx. 5/3.

= 0.393700 gram calorie, centimetre cube unit; approx. 4/10.

1 gram calorie, centimetre cube unit:

= 4.18617×10^{7} c.g.s. units of conductivity.

= 10.6329 thermal mho, inch cube units; approx. 21/2.

= 4.18617 thermal mho, inch cube units; approx. 50/12.

= 2.54001 gram calories, inch cube units; approx. 10/4.

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Book Reviews

DESIGN OF MINE STRUCTURES. By Milo S. Ketchum. 449 pp.; index. McGraw-Hill Book Co., New York. For sale by the *Mining and Scientific Press*, San Francisco, California. Price $4.

Examination of the teeth of a gift-horse is a proverbially ungrateful action, and to attempt to criticize the only book upon an important topic is perhaps an action of the same character. Mr. Ketchum has undoubtedly imposed a burden of obligation upon engineers by the preparation of a volume upon the design of mine structures. This is a phase of engineering work which is of great importance, but upon which, beyond the lecture courses in a few of the more important mining schools, there has been little data available except in scattered and disjointed form. It is unnecessary to recite the obvious; therefore, no attempt will be made to indicate how much better this book is than no book at all. It will be more profitable, however, to consider how far it falls short of being the best book which might be written upon this subject. The title is misleading, and from a perusal of the subject-matter it would appear that 'the mechanical design of mine structures' would have been more appropriate, as no considerations other than mechanical ones enter into the discussion; except in a few instances as regards the structures required at coal mines, with which the author seems to be more familiar, as is shown by such statements as that "push-back coal tipples are slow and expensive on account of the excessive hand labor required." The engineer who consults this volume in the hope of finding guidance as to the choice of structures to meet specific conditions is doomed to disappointment. He will find information as to the design of several types of steel head-frame which have been erected at various points, but will find no information for his own guidance in the choice of a type. Where Mr. Ketchum does venture criticism of types, his remarks are not especially helpful, as, for example, his statement that the four-post timber head-frame is satisfactory but is expensive for high frames on account of the cost of obtaining the timber. The data given on the design of structures is merely fundamental and can be obtained in any text-book on structures. The discussion on skips and cages is quite disappointing. A number of illustrations and line-cuts are given, showing various designs of cages and skips that have been used under various conditions, but no information is given that will assist a designing engineer not thoroughly familiar with the subject, in designing a cage or a skip to meet his own conditions. Knowledge on this subject is confined to a comparatively few men in the employ of various manufacturers, specializing in this class of work, and it is a matter of regret that Mr. Ketchum did not go into this branch of the subject more thoroughly, so that others could acquire a knowledge and understanding of the requirements and the methods for designing self-dumping, automatic, ore-handling apparatus. The greater part of the information published on the design of shapes, trusses, and other structural forms is compiled from the hand-books published by the Carnegie Steel Co., American Bridge Co., and other manufacturers. The book as a whole is principally a compilation rather than an original work. As a compilation it will be of undoubted service to users as a matter of convenience. As an original work it is disappointing in view of what appears to us to be a failure to embrace an opportunity to create a thorough and comprehensive book to fill a long-felt want.

PROCEEDINGS OF THE FOURTH MEETING OF THE ILLINOIS WATER SUPPLY ASSOCIATION HELD AT THE UNIVERSITY OF ILLINOIS, MARCH 1912. The Illinois Water Supply Association was instituted four years ago for the purpose of promoting intercourse and the exchange of ideas among its members. A great many valuable technical papers were presented at the meeting, among which may be mentioned 'The Limitation of Stream Pollution,' by Paul Hanson of the Water Survey; 'Characteristics of Typhoid Fever Outbreaks,' by H. M. Parker of the University of Illinois; 'Hypochlorite Sterilization and Typhoid at Kansas City, Mo.,' by W. M. Cross, city chemist of Kansas City; and 'Pumping by Steam and Electricity,' by E. MacDonald of Lincoln. The Illinois Water Supply Association as a whole is doing a notable work, and it would greatly benefit California if a similar association could be formed.

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Engineering Bonds

*Tax exempt in California.
†Legal investment for savings banks in California.
‡Available as security for deposit of state, county, and municipal funds and postal savings deposits.

THE COAST COUNTIES LIGHT & POWER CO. has issued $1,000,000 first mortgage, 5% gold sinking-fund bonds, due August 1, 1946.

Senior to these bonds are two issues, secured by first mortgages on divisions of the general property, of which $470,000 is outstanding. Following the bonds is $2,000,000 outstanding stock, half preferred and half common.

John Martin, president of the company, makes the following statement: "This is a closed issue, secured by direct first mortgage. In addition to the property originally owned by the Coast Counties Light & Power Co., on which these bonds are a first lien, they now cover the property subsequently acquired from the Big Creek Light & Power Co. and the San Benito Light & Power Co., subject only to the bonds outstanding on those properties at the time of their acquisition. A detailed appraisal of physical property shows the replacement value of the property covered by these bonds to be in excess of the total amount of bonds outstanding, without any allowance for franchises, good will, going value, or other intangible assets. The net income of the company, available for bond interest, is double the total interest charge on these and other bonds outstanding, specified in the accompanying table.

The earnings of the property covered by the Coast Counties Light & Power Co.'s bonds are as follows:

Year ended December 31:	1910.	1911.
Gross earnings from sale of gas and electricity	$235,823.58	$268,308.37
Other income	1,350.70	5,616.11
Total earnings from operation	$237,174.28	$273,924.48
Operating expenses, maintenance, and taxes	137,984.05	144,696.13
Net earnings from operation	$ 99,190.23	$129,228.35
Net profit received from Union Traction Co.	13,847.12	13,655.39
Total net income available for bond interest	$113,037.35	$142,883.74
Bond interest	63,560.00	69,560.00
Surplus	$ 49,477.35	$ 73,323.74

*The Metropolitan Gas Corporation, a company subsidiary to the Pacific Gas & Electric Co. of San Francisco, has issued $950,000 in first-mortgage 5% sinking-fund gold bonds, dated November 25, 1911, due December 1, 1941; denominations are $500 each. The Metropolitan Gas Corporation 5% bonds originally assumed by the San Francisco Gas & Electric Co. in addition to having become a direct obligation of the Pacific Gas & Electric Co. are secured by a direct first mortgage on the entire physical property of the former Metropolitan Gas Corporation, the duplication value of which is estimated by competent engineers to be in excess of the total issue of $1,368,000 without taking into consideration the value of franchises, good-will, or other intangible assets. The Pacific Gas & Electric Co. has officially reported as follows:

CAPITALIZATION

(Pacific Gas & Electric Co.)

Stock—	Outstanding.
Common (5%)	$28,908,750
Preferred (6%)	10,000,000
Bonds—	
Metropolitan Gas Corporation first 5's (closed mortgage)	1,368,000
Pacific Gas & Electric Co. general and refunding mortgage 5's	20,000,000

EARNINGS

(Pacific Gas & Electric Co.)

Year ended Dec. 31.	1911.	1910.
Gross earnings	$14,604,609	$14,044,596
Operating expenses, maintenance, and taxes	8,214,072	7,921,341
Net earnings	6,390,537	6,123,255
Interest on Metropolitan Gas Corporation first 5's and other underlying bonds	2,555,745	
Balance	3,834,792	

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Engineering News

Power, Gas, and Electricity

San Francisco.—Statement of the Great Western Power Co., which includes at the same time that of the California Electric Generating Co., and the City Electric Co., for the five months ended May 30, 1912, is as follows:

	1912. May.	1912. 5 months.
Gross earnings	$182,531.92	$903,436.71
Operating expenses and taxes	76,731.03	347,681.42
Earnings over operating exp. and taxes	105,800.89	555,755.29
Other income	1,405.66	5,606.50
Total	$107,206.55	$561,361.79
Bond interest	82,695.09	415,354.05
Surplus	$24,511.46	$146,007.74
Accrued dividends on California Electric Generating Co. preferred stock (guaranteed by Great Western Power Co.)	11,450.00	50,350.00
Balance of surplus after payment of above dividends	$13,061.46	$95,657.74

The State Railway Commission has granted a certificate of public necessity to the Oro Electric Corporation, granting it permission to build a reservoir and power house in Humbug valley, Plumas county, and to extend its lines through Butte, Yuba, Sutter, Colusa, Glenn, Yolo, Solano, Contra Costa, Sacramento, San Joaquin, and Calaveras counties.——Permission has been granted to the Northern Electric Railroad Co., Marysville and Colusa branch, by the State Railroad Commission to issue $600,000 of 5% bonds. The proceeds of this issue are to be used for the construction of the Marysville and Colusa branch of the Northern Electric Co. and for a branch across the Sacramento river at Meridian.——The Western States Gas & Electric Co. has applied to the Railroad Commission for authority to issue $600,000 of 5% bonds, the proceeds to be used for the acquisition of property and water rights in El Dorado county known as the Summerfield ditch.——The Pacific Gas & Electric Co. has applied to the Railroad Commission for approval of a contract under which it will acquire by purchase the Los Gatos Ice, Gas & Electric Co. for the sum of $187,762.51. The Northern California Power Co. has applied to the Railroad Commission for permission to issue $500,000 of five-year 6% debenture notes for the liquidation of floating indebtedness.——The Southern Sierra Power Co., has applied to the Commission to reduce and modify its rates for electricity in Inyo, Kern, and San Bernardino counties.

San Jose.—The Peninsula Railroad Co. has commenced construction of a branch line from San Jose to Alum Rock park.

Los Angeles.—The Los Angeles Gas & Electric Corporation will build a 1,000,000 cu. ft. gas container at Pasadena.

Seneca (Plumas county).—The Indian Valley Electric Light & Power Co., O. C. Pratt president, with offices in the Crocker building, San Francisco, has acquired water rights in Indian valley, American valley, and Genesee valley in Plumas county, where a minimum flow of 500 second feet has been secured with which 31,500 hp. can be developed at the switch-board with 70% plant efficiency, according to engineer's report made by Heinreich Homberger. A transmission system is proposed to be laid out as a single-pole line which will give service to the various mines and industrial enterprises around Indian valley.

Boise, Idaho.—The Idaho Railway, Light & Power Co., capital stock $30,000,000, has been organized by an association of New York bankers. The property acquired by the new company includes the following: A hydro-electric plant formerly owned by the Swan Falls Power Co. at Swan Falls, on the Snake river, about 27 miles southwest of Boise. Present capacity 4000 kw. This plant furnishes the Idaho-Oregon Light & Power Co. with its power, and the latter company owns and operates transmission lines to Murphy, Dewey, Silver City, Nampa, and Caldwell, Idaho. The properties formerly of the Dewey Electric Light & Power Co., furnishing electric light to the city of Nampa. The properties and franchises formerly of the Caldwell Power Co., furnishing electric

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light to the city of Caldwell. An interurban trolley line, Boise & Interurban railway, extending from Boise City to Caldwell, Idaho, about 35 miles. An interurban trolley line extending from Boise City to Nampa, about 27 miles. An interruban trolley line extending from Nampa to Caldwell, about 8 miles. A majority of both the $7,485,700 outstanding common stock and the $2,491,000 preferred stock of the Idaho-Oregon Light & Power Co.; also about $1,443,000 of its 'consolidated first and refunding mortgage' 6% gold bonds, being all but about $170,000 of said issue now outstanding.

Irrigation and Water Supply

Oakland.—People's Water Co. has applied to the Railroad Commission asking permission to issue notes amounting to $500,000 for the purpose of refunding existing obligations.

Montague (Siskiyou county).—G. W. Dwinnell has purchased about 8000 acres of land upon which he will place pumping plants, ditch lines, etc., for irrigation purposes.

Pasadena.—Ordinances providing for the issue of $1,250,000 in bonds bearing 4½% interest have been presented before the city council. The funds to be acquired will be used for municipal water supply improvements.

Miscellaneous Engineering Construction

Cement Production.—During the past 13 years the production of cement in the United States has shown an annual increase and the growth of the portland cement industry has been enormous. This is indicated by the fact that the two million barrel increase in production in 1911 was the smallest that has been recorded within these 13 years. The total production of portland cement in the United States in 1911, according to Ernest F. Burchard, of the United States Geological Survey, in the advance chapter on cement from 'Mineral Resources for 1911,' was 78,528,637 bbl., valued at $66,248,817. Although the increase over the production of 1910 was 1,978,686 bbl., or 2.58%, the total value decreased $1,956,983, or 2.87%. The average price per barrel in 1911 was a little over 84c., compared with 89c. in 1910. The average price of portland cement in the Lehigh district was 71½c. per barrel, and that on the Pacific coast $1.40½. Many mills in the East and Middle West, according to Mr. Burchard, sold cement as low as 65c. per barrel. The portland cement plants reported in operation numbered 115, an increase of 9 over the number in the preceding year. The total production of natural cement in 1911 was 629,091 bbl., valued at $378,533, and of puzzolan cement 93,230 bbl., valued at $77,786, making a grand total for all cements of 79,547,958 bbl., valued at $66,705,136.

San Francisco.—A contract has been awarded by the Board of Public Works to the Contra Costa Construction Co. for laying mains for the auxiliary water-supply system in the district south of market street, between 2nd and 11th streets, at a price of $159,043.

Oakland.—The Board of Supervisors has passed a resolution for the construction of a reinforced concrete bridge at Niles. The bridge will be built according to general plans submitted by the State Highway Commission and will form a part of the new state highway system. It will be made of reinforced concrete and will have a 24-ft. roadway with sidewalks on each side. There will be five spans, the distance between arches being 512 ft. The maximum cost has been fixed at $65,000. The City Council will appropriate $35,000 for the construction of the steel and concrete bridge over the creek through which the tide waters ebb from Lake Merritt at 8th street. William J. Baccus is Commissioner of Streets.

Martinez.—The Board of City Trustees has awarded the contract for the construction of the Martinez municipal wharves to the Mervey-Elwell Co. for the sum of $31,340.

Sacramento.—At a special election held on July 23 a bond issue of $887,000 for the purpose of protecting the city from floods was approved by the voters. The plan proposed includes raising the present levees and the construction of a by-pass through the levee at Bryte ranch on the Yolo side of the river. George M. Randall is city engineer. The city of Sacramento has made plans and estimates for the construction of a complete new sewer system for the outlying territory.

Los Angeles.—Plans have been made for the improvement of the Huntington area and Wilmington channel by E. P. Goodrich, consulting engineer, and Homer Hamlin, city

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engineer. A permanent wharf will be built 2400 ft. long and 40 ft. wide of concrete and steel construction, approximate cost $360,000. The amount to be spent for wharf structure for freight handling, machinery, etc., will amount to $350,000. Temporary wharves are to be built at various points to meet present needs and ultimately a nine-slip set of wharves will be constructed. One million dollars in all has been appropriated for harbor improvements, of which $300,000 for dredging and filling has already been contracted for. The Rivers and Harbors bill as amended in the Senate provides an appropriation of $327,250 for dredging the Los Angeles outer harbor. Plans for temporary wharf construction include a 1000-ft. wharf, 50 ft. wide, with creosoted wooden piling, estimated cost $62,070; a similar wharf, 150 ft. long, 60 ft. wide, estimated cost $73,000; 1000-ft. concrete pile wharf, 50 ft. wide, $78,940; 1050-ft. concrete pile wharf, 60 ft. wide, $86,250. A channel 2200 ft. long, 200 ft. wide, and 30 ft. deep will be dredged, estimated cost $88,000. Plans for the improvement of Wilmington basin call for dredging a 200-ft. channel 1700 ft. long, estimated cost $96,000; 600 ft. of permanent wharf, estimated cost $66,000; a shed 100 by 600 ft., estimated cost $60,000; a permanent wharf at Water street, 400 ft. long, estimated cost $44,000; a temporary wharf, 400 ft. long, estimated cost $24,828; and a temporary wharf at Fries street, 400 ft. long, estimated cost $20,400. Canal street is to be improved with a strip of asphalt pavement 20 ft. wide, estimated cost $3200. A spur track will be built, estimated cost $4250. Total cost of improvements for the Wilmington basin, $318,678. Contract for filling 20 blocks in Wilmington harbor has been awarded to the Standard American Dredging Co. for the sum of $89,852.13, on the basis of 9 to 10c. per cubic yard.

Redlands.—The Union Ice Co. of Los Angeles is contemplating an erection of a $253,000 pre-cooling plant at Redlands.

Redondo Beach.—The Pacific Electric Co., in conjunction with the Chamber of Commerce of Redondo, is contemplating the construction of a municipal pleasure pier. P. H. Albright, of the Pacific Electric Co., is the engineer in charge.

Long Beach.—Contract for the reconstruction of the Pine Avenue pier has been awarded to the Mercereau Co. for the sum of $26,680.

Hermosa Beach.—A reinforced concrete pier will be built by the city at an approximate cost of $100,000; entrance to the pier will be 100 ft. wide for a distance of 300 ft., remaining 700 ft. will be 25 ft. in width.

Douglas, Arizona.—The New State Telephone & Telegraph Co. has been incorporated at Tombstone, capital stock $100,000. The incorporators are D. A. Adams, T. J. Riggs, H. A. Morgan, J. H. Snyder, and A. Y. Smith.

Railways

San Francisco.—United Railroads of San Francisco have made a report to the Board of Supervisors of receipts during the year 1911 for the lines upon which it pays franchise percentages to the city. The receipts of the 2% lines, according to the report, were $1,833,739.97 last year, and the amount due the city on them is $36,674.78. On the 3% lines the receipts amounted to $84,717.35, and the city's percentage is $2541.51. The Sixth and Sansome street line pays 4%, and as the receipts on it were $13,778.37, the city's share is $551.12. The whole sum to be paid to the city is $39,767.41. The Railroad Commission has been asked for permission by the United Railroads to issue $300,000 in equipment trust certificates to provide funds for the purchase of 65 new cars. The Southern Pacific company has awarded contract to the Utah Construction Co. for the construction of 15 miles of double track connecting Truckee, California, and Reno, Nevada.—— The Western Pacific railroad has let contract to the Utah Construction Co. for the construction of 9½ miles of track known as Arnold's loop, near Proctor, Nevada.——The Northwestern Pacific railroad has let contract for the last 43 miles of its line from San Francisco to Eureka to the Utah Construction Co.; $2,000,000 will be expended by the railroad company on the section extending from Ft. Seward to Covelo bridge near Laytonville.

Stockton.—Central California Traction Co. will double the capacity of its repair shops at this point, including the erection of a complete new woodwork plant.

Los Angeles.—San Diego, Riverside & Los Angeles Railway Co. has been incorporated

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together with the Southern California Utilities Co. and the Universal Construction & Investment Co. The first two have authorized capital stock of $10,000,000 each and the last of $2,000,000. The directorate of the Utilities company is composed of Charles E. Weite, M. M. Millice, and Lamonte Simms, of Riverside, and W. S. Belonbet and Maurice Salzman, of Los Angeles. The incorporators of the construction company are J. W. Schmitz, J. M. Perrine, L. B. Oberz, Harvey G. Beeson, and Stewart Kendall. It is said that the route of the new railroad will extend between Los Angeles, Riverside, and San Diego. Thomas McCaffrey has been appointed superintendent of construction. The city engineer has prepared plans and estimates of cost for laying tracks, passenger and freight stations, car barns, and purchasing cars and other equipment for the proposed railroad to the harbor. Figures total $2,268,551, made up as follows:

4.72 miles double track and pavement in streets	$327,096
15.56 miles double track on private right of way	553,438
4.72 miles distributing system in city streets	23,295
15.56 miles distributing system on private right of way	33,532
20.28 miles transmission line	49,199
Special work, interlocking and side tracks	136,800
Terminal tracks and power lines, Los Angeles	12,000
Bridges, trestles, culverts	12,000
Fencing, 16 miles	11,200
Substations, 3	78,000
Shop building, yard tracks, and shop equipment	61,150
Los Angeles freight house	40,000
Los Angeles car-barn	15,000
Los Angeles passenger depot	18,000
Stations between Los Angeles and the harbor	6,400
Equipment, cars, locomotives, etc.	723,400
	$2,100,510
Engineering and legal expenses, 8%	168,041
Total	$2,268,551

Portland.—Southern Pacific Co. has announced plans for an electric railway terminal; a steel bridge across the Willamette river; a four track system between Oswego and Aurora; electrification of 340 miles of railroad between Portland and outlying districts in western Oregon.——Southern Pacific has secured the Portland, Eugene & Eastern railroad, Salem, Falls City & Western railroad, and Canby, Mollawla railroad. The improvements contemplated will total an outlay in excess of $18,000,000 before the work has been completed.

Denver.—Denver & Rio Grande railroad, E. L. Brown vice-president, has authorized improvements consisting of new bridge construction, re-ballasting, and grade ratification which will cost in excess of $1,000,000.

Streets and Roads

Sacramento.—The California State Highway Commission has adopted the survey for the proposed roads across Yolo basin between Sacramento and Davis. The survey has been ordered for the proposed road from Redding, Shasta county, to Coles, near the Oregon line. Bids will be asked for the construction of sections through Stanislaus, Madera, Fresno, San Diego, Santa Clara, and Merced counties, aggregating 69 miles, estimated to cost $400,000, in detail as follows:

On general route No. 4, from Sacramento to Los Angeles, via the San Joaquin valley, 11.7 miles in Stanislaus county, from the Merced county line to a point one and one-half miles north of Ceres. Bituminized concrete. High estimate, $90,000.

On general route No. 4, seven miles in Madera county, from a point one mile south of Califa to the Merced county line. Bituminized concrete. High estimate, $56,000.

On general route No. 4, same as foregoing, ten miles in Madera county, from the Fresno county line to Madera city. Bituminized concrete. High estimate, $81,000.

On general route No. 4, same as foregoing, 7.5 miles in Fresno county, from Fresno city to the Madera county line. Bituminized concrete. High estimate, $78,000.

On general route No. 2, San Francisco to San Diego via Los Angeles, 8.6 miles in San Diego county, from San Diego to Encinitas. Bituminized concrete. High estimate, $66,000.

On general route No. 4, Sacramento to Los Angeles, via the San Joaquin valley, ten miles in Merced county, from the north county line of Merced to Arena. Bituminized concrete. High estimate, $80,000.

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Redwood City.—An election will be held on December 16 to ratify a proposed issue of $1,500,000 in bonds for the construction of a system of boulevards in San Mateo county.

Petroleum

June production of oil, according to the *California Oil World*, is as follows:

Field.	Fuel.	Gross.
Coalinga	66,491	1,644,265
Kern River	175,000	1,104,863
McKittrick	28,201	533,175
Maricopa	45,749	450,772
Midway	72,480	2,061,552
Lost Hills	7,800	115,356
Santa Maria-Lompoc	11,750	443,192
Fullerton	11,239	479,907
Salt Lake	2,225	247,059
Los Angeles City	1,500	33,342
Summerland	600	4,950
Whittier	2,675	57,969
Coyotes-La Habra	490	79,503
Newhall	515	10,699
Ventura	5,250	61,226
Total	431,965	7,327,830

Following are stocks, June 30, 1912:

	Field.	Pipe-line.	Total.
Coalinga	405,872	2,679,063	3,084,935
Kern River	387,360	27,484,386	27,871,746
McKittrick	84,450	.....	793,231
Maricopa	436,925	275,695	712,630
Midway	419,675	1,318,104	1,737,779
Lost Hills	20,100	207,438	227,538
St. Maria-Lompoc, Cat C'n.	372,751	256,002	628,753
Fullerton	89,784	166,512	156,296
S. Lake-Shr'n.	143,458	46,867	190,325
L. A. City	15,000	489,279	504,279
Whittier	39,900	.....	30,900
Coyotes-La Hab.	23,888	.....	23,888
Newhall	3,079	.....	3,079
Ventura	44,289	45,734	90,023
Miscellaneous	.....	8,763,860	8,763,860
Total	2,477,541	42,441,721	44,919,262

San Francisco.—The Standard Oil Co. is considering the construction of two 500,000-bbl. capacity storage reservoir in the Kern River oilfields.——The General Petroleum Co. has purchased the property of the Bear Creek Oil & Mining Co., consisting of 420 acres of oil land in the North Midway field, for approximately $1,500,000.

Taft.—Associated Oil Co. has brought in a 35,000,000-cu. ft. gasser in section 20, 31-23.

Santa Maria.—Santa Maria Valley railroad, which extends from Guadalupe on the Southern Pacific through Santa Maria to Sisquoc and the Palmer properties of the Santa Maria Oilfield, Ltd., is to be extended through the eastern end of Cat Canyon to Los Olivos and a point north of Santa Barbara.

Los Angeles.—Producers' Transportation Co. will parallel its 8-in. pipe-line between Avila and the junction of the Coalinga and Kern county lines, a distance of 75 miles. Five pumping stations will be installed.——Associated Oil Co. has commenced preliminary arrangements for the construction of a pipe-line 165 miles long to extend from the Midway district to the outer San Pedro harbor. Pumping plants and tankage to take care of the large amount of oil to be handled are included in the project.——The Midway Gas Co. has commenced preliminary work of installing the second pipe-line to parallel the first, between Los Angeles and the Midway field.

Panama-Pacific Exposition

The building and ground committee has awarded a contract for filling in the lowlands on the Presidio reservation and also on that part of the site bounded by Lyon, Lombard, Beach, and Baker streets for the sum of $87,300. Work is to be completed within 180 days.

Work on the Fair site is making rapid progress. Seventy buildings have been removed, and it is expected that within 30 days the ground will be entirely cleared. Condemnation suits have been brought against the owners of nine pieces of property west of Laguna street and ten pieces east of Laguna and west of Van Ness avenue. It is expected that construction work will be rushed as soon as all of the ground has been secured. Bids will be called for soon for the construction of the fence for enclosing the grounds. The sea-wall is almost completed. Caldwell & Co., contractors for this work, have hauled more than 15,000 cu. yd. of stone. Another suction dredge is in operation filling in the overflow at the Harbor View site. Both dredges are working night and day and are pumping 20,000 cu. yd. of silt and depositing it for filling.

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Markets

MATERIALS FOR CONSTRUCTION

(San Francisco prices, July 29.)

Shapes—Angles, tees, and channels, 3 in. and under, $2.45 per 100 lb.; over 3 in., $2.25 per 100 lb.; I-beam, 4 in. to 15 in., $2.35 per 100 lb.

Bar Steel—Rounds and squares, $2.35 base per 100 lb.

Wire Nails—$2.60 base per 100 lb.

Black Sheet Steel—No. 18-20, $3.55; No. 22-24, $3.60; No. 26, $3.65; No. 27, $3.70; No. 28, $3.75; No. 30, $3.95.

Steel Plates—No. 16, $2.90; No. 14, $2.80; No. 12, $2.75; No. 8, $2.40; No. 10, $2.55; 3/16, $2.35; ¼ in. and heavier, $2.25; all per 100 lb.

Rails—Steel T, 8-lb., $2.15; 12-lb., $2.05; 16-lb., 20-lb., and 30-lb., $2.

Pig Iron—No. 1 Scotch, $25.00 to $27.50.

Coke—German Syndicate, forked foundry, $14 to $15 per long ton; average to arrive ex-ship, $14 to $15 per long ton.

Portland Cement—In sacks, $2.50 per bbl.

Lime—$1.50.

Fire-Brick—Imported Carr, Cowen, or Snowball, $50 per 1000; domestic Livermore, $38 per 1000.

Fire-Clay—$10 per ton.

OIL SHARES

(By courtesy of San Francisco Stock Exchange, July 27.)

	Bid.	Ask.		Bid.	Ask.
Assd Oil	43.25	..	Pinal	4.25	..
Brookshire.	.40	..	Premier	.40	.50
Caribou	.75	..	Republic	.32	..
Claremont.	.65	..	Sauer D.	1.20	..
Coal Cent'l.	.20	..	S W & B.	.20	..
De Luxe	.75	..	United Oil.	..	.28
Maricopa 36	.20	.30	W Cst pfd.	65.00	100.00
New Pa Pet	.53	..	W K Oil.	2.00	2.25
Palmer	.41	..			

CALIFORNIA OIL DIVIDENDS FOR JUNE

(As reported by the San Francisco Stock Exchange.)

	Rate.	Amount.
Amalgamated	$1.000	$50,000.00
Caribou	0.010	8,070.30
Claremont	0.010	5,000.00
Columbia	0.010	9,992.26
Home	0.010	1,000.00
Monte Cristo	0.025	12,500.00
New Pennsylvania	0.005	2,500.00
Premier	0.010	10,000.00
Record	0.050	5,000.00
Sauer Dough	0.015	2,992.50
Section 25	0.500	20,000.00
Shawmut	0.020	10,000.00
Silver Tip	0.050	3,750.00
W. K.	0.020	10,000.00

SAN FRANCISCO QUOTATIONS.

(San Francisco Stock & Bond Exchange July 27.)

LISTED

	Bid.	Ask.		Bid.	Ask.
Assd Oil 5.	102	..	Oak W g 5.	..	95½
Bay C P 5.	101¼	..	Om Ca R 6.	101½	..
C C G&E 5.	101¾	103¾	Oro Elec 6.	98¼	..
C E ser A 5	87¼	..	Pac Gs I 4.	89	..
C G & E 5.	..	102	Pac G&E 5	91⅞	92⅛
do Un 5.	95⅛	..	Pac E R 5	..	104¾
Cal st Ca 5.	102	..	Pac L & P 5	96¾	..
Cen C T 5.	..	95¼	do gtd 5.	100	101¼
City El 5.	89¾	90¼	Pac T&T 5.	100¾	101¼
CCL & P 5	93⅞	..	P & C H 6.	..	100½
C C Wat 5.	..	100	P & O R 6.	100	..
do g m 5.	94⅛	95½	Peo Wat 5.	75¾	76
E E L A 5.	101½	102½	S E G&R 5.	103¼	..
E L & P 6.	105	..	S D & Cy 5	97	..
F & C H 6.	100	100½	S J L&P 5.	99⅜	99⅝
Gt W Pr 5.	88¼	88½	do ser A 6.	101¾	..
H R T&L 6.	105½	..	S F E R 5.	..	90
Lk Tahoe 5.	..	98	SFN&CR 6.	102	..
L B Gas 6.	100¼	..	SFO&SJ 5.	104⅝	105¼
Ls An E 5.	100	101½	do 2m 5.	..	96⅝
L A G&E 5.	..	100¼	do Con 5.	..	93¼
do Corp 5.	..	98½	SJ&SC 4½.	..	92
Ls An R 5.	..	107⅞	S B G&E 6.	100	..
do Corp 5.	98	..	S R of C 6.	..	102
L A Lt g 5.	100	..	S P 1c g 5.	..	112¾
L A-P 1c 5.	104½	..	S P Br C 6.	126½	..
L A-P C 5.	100	..	SP 1st ref 4.	94⅜	94¾
Mar W&P 5	..	100	S V g m 4.	93⅝	..
Mktst Ca 6.	100	..	U G & E 5.	100⅞	..
do 1c m 5.	..	92	U R S F 4.	..	66
M C G&E 6	99½	..	Val C P 5.	101¼	101¾
MV& MT 5.	100	..	Water Stocks—		
Nat Con 6.	93¾	..	Marin Co.	53½	..
N R of C 5.	112⅜	..	Peo W pfd.	50⅜	..
N Cal R 5.	106	..	Spg Val.	62	..
N Cal Pr 5.	100⅜	..	Gas & Elec Stocks—		
do Con 5.	..	92½	NCal Pr Cn	..	50
N Elec 5.	93½	93¾	Oro El pfd.	76	..
O G L&H 5.	100½	101½	do com	18	19
Oak Tra 6.	107½	..	Oro Wat.	100	..
do 5	..	105½	Pac Lt pfd	73¼	..
do Con 5	..	103	do com	78	..
Oak Tr c 5.	..	98½	Street R R Stocks—		
do 5	90½	91¼	California .125		..

UNLISTED

	Bid.	Ask.		Bid.	Ask.
Am RivE 5.	95	..	Std Elec 5.	92½	94
Bay C P 6.	102½	..	S P Cem 6.	92	..
Blue LW 6.	102½	..	U L & P 6.	..	99½
Cal N W 5.	104	..	West Pac 5	83	83¼
CVG&E 1st 6	100	101	Cal EG pfd	80	85
Gen Pet 6.	..	74	Gen Pet	16	..
M W P 6.	101½	..	K Rte pfd	72	73
Mut El 5.	97	..	Nat Con.	13½	14½
NatCon2d 6	71½	..	Noble Elec	22½	24
O & A 5.	..	83	Oak & Ant	20	25
Oak Ry 6.	101	102	Ocean Shore		
OWL&P 6.	101	..	new stock	12	18
P P Cem 6.	100	..	Oak Tr pfd	..	82½
P&SRR 1st 5	94	..	do com.	..	40
do 2d 6.	.92	..	Oro Dev	45	..
Phil Tel 6.	97½	..	PG&E pfd.	93¾	94½
SF&NP 5.	104¼	104¾	do com.	66⅛	66½
SF&SJV 5.	111	111½	P P Cem.	..	77½
S F G & E.	92⅛	92¾	Peo W com	3⅛	3½
do callable	93	94½	P&SR Ry.	20	..
SCPCem 6.	89½	90	Riv Cem	..	47½
S&SF 1st 5.	..	97½	S C P Cem.	37½	44
S Cal Ed 5.	..	98	West Pac.	6½	8
SPacCst 5.	93⅝	95	W Pow com	34	35
S Y Wat 6.	106	107½	do pfd	60	61

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Engineers' Note Book

ACCORDING to the Handbook of Steam-Shovel Work published by the Bucyrus Co., the following formulae may be used to determine the approximate cost of steam-shovel work:

d = time in minutes to load 1 cu. ft. with dipper (place measure).
c = capacity of one car in cu. ft. (place measure).
f = time shovel is interrupted while spotting car.
e = time shovel is interrupted to change trains.
g = time to move shovel.
l = distance of one move of shovel.
n = number of shovel moves.
m = minutes per working day less time for accidental delays.
A or B = area for shovel section excavated in square feet.
R = cost per cubic yard on cars, in cents, for shovel work only (place measure).
LAN = cubic feet excavated per day.
C = shovel expense, in cents, one day, not including superintendence and overhead charges and not including preparatory charges.
N = number of cars in train.

(1) Time to load 1 car = dc.
(2) Time to load 1 train = $ndc + nf + e$.
(3) Number of trains for 1 shovel move = $\frac{LA}{nc}$

Time between beginning of 1 shovel move and beginning of next =

(4) $(ndc + nf + e)\frac{LA}{nc} + g$

(5) $N = \frac{M}{(dc + f + \frac{e}{n})\frac{LA}{c} + g}$

(6) $R = \frac{27Cd}{M} + \frac{27C}{M}\left(\frac{f}{c} + \frac{e}{nc} + \frac{g}{LA}\right)$

This is the equivalent of the equation $R = md + b$

(7) Where $m = \frac{27C}{M}$ and

(8) $b = m\left(\frac{f}{c} + \frac{e}{nc} + \frac{g}{LA}\right)$

A COMPARISON according to Reid T. Stewart in the *Journal* of the American Society of Mechanical Engineers, April 1912 issue, of the theoretical formulae for the strength of steel tubes, pipes, and cylinders under internal fluid pressure, shows that:

(a) Clavarino's formula is theoretically correct for cylinders with attached heads, and Birnie's formula for heads held independently. These formulae are practically applicable to certain classes of seamless steel tubes and cylinders and to critical examination of ordinary commercial steel tubes, pipes, and cylinders when sufficiently accurate data are available.

(b) In commercial welded pipe the variation in thickness of wall, perfection of weld, etc., account for variation in bursting strength of sufficient magnitude to render unnecessary any consideration of Clavarino's or Birnie's condition of head support. All such variations give rise to errors on the side of danger when applying these formulae.

(c) For ordinary commercial wrought pipe Barlow's formula is to be preferred. This formula is:

$$\frac{p}{f} = 2\frac{t}{D};\ p = 2f\frac{t}{D};\ t = \tfrac{1}{2}D\frac{p}{f};\ f = \tfrac{1}{2}D\frac{p}{t}$$

where D = outside diameter in inches
t = nominal or average thickness of wall in inches
p = internal fluid pressure in lb. per square inch
n = safety factor as based on ultimate strength
f = fibre stress in lb. per square inch
$= \frac{40{,}000}{n}$ for butt-welded steel pipe
$= \frac{50{,}000}{n}$ for lap-welded steel pipe
$= \frac{60{,}000}{n}$ for seamless steel tubes
$= \frac{28{,}000}{n}$ for wrought iron pipe

APPROXIMATE power required for pumping may be determined by the formula

$$hp = \frac{gpm \times h}{2000}$$

where gpm is gallons pumped per minute and h is total vertical lift in feet. Friction head is neglected and 50% efficiency is assumed for the pump. The following formula is exact for fresh water:

$$hp = \frac{gpm \times (h + f)}{3960 \times e}$$

where f = friction head and e = efficiency of pump expressed as a percentage.

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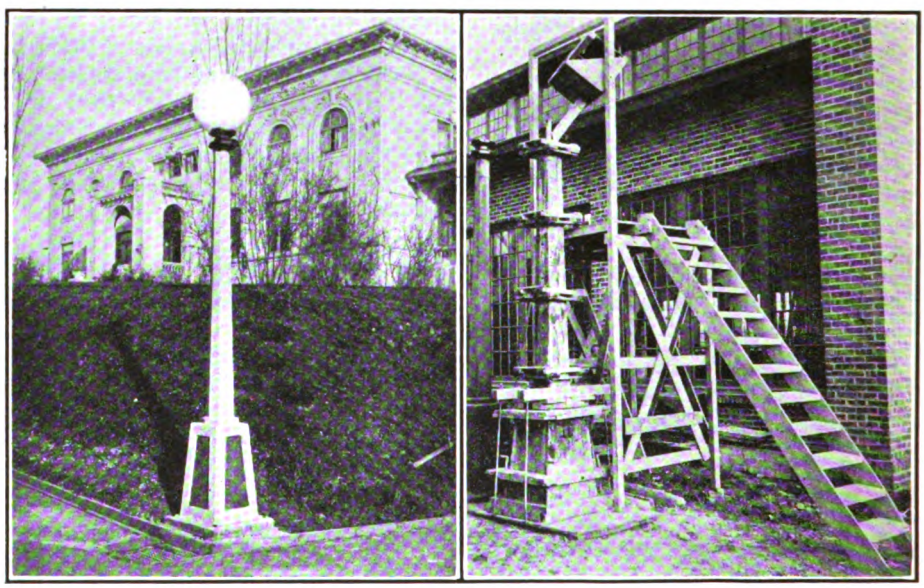
Industrial Progress

Ornamental Concrete Electroliers

By H. L. QUIGLEY

The primary function of an ornamental illuminating standard is appreciably enhanced by its harmony with and adaptation to any artistic scheme of park development. In a lesser way it is possible to obtain a true index of the character of a community by the number of lamp posts and the state of their development, the same as the amount and quality of permanent pavements reflect the municipal progress of a city. That the increasing use of portland cement is not solely confined to pavement-base or massive structures of various purely commercial needs, is attested by the monolithic concrete lamp posts successfully doing their work and incidentally raising the standard of artistic urban decoration in a number of cities on the Pacific slope. Two typical examples are taken for detailed citation in the concrete lamp posts now on the campus of the University of Washington in Seattle, and those on the public streets of Riverside, California.

At present 78 posts cover the most important part of the campus, or about one-fifth of its total area. The system will be enlarged and completed when possible by a further state appropriation. Throughout the work represented in these concrete posts the idea of 'Washington' has been carried out. The design was by a University of Washington instructor, the entire labor was furnished by student engineers during their vacations, the castings necessary were designed and made at their foundry, and while several brands of cement were experimented with, the portland cement used was made on the Pacific coast.



CONCRETE ELECTROLIER AT UNIVERSITY OF WASHINGTON, SEATTLE, FINISHED AND UNDER CONSTRUCTION.

The concrete was hand-mixed in proportion of 2 parts cement to 5 parts gravel without the use of any sand. The pea gravel was hand-screened through 3 mesh, and all undersize caught on another screen of 6 mesh was used. The wooden forms and the method of pouring is clearly shown in the accompanying illustration. After an average time of 18 hours from the completion of the pouring, the molds were removed and the surface wire-brushed. After a three days' set, the surface was then given a one-half strength muriatic acid (commercial) bath. When the cement was eaten down sufficiently to make the gravel stand out prominently, the pole was liberally sprinkled from a hose.

Each sub-base and the necessary wiring for

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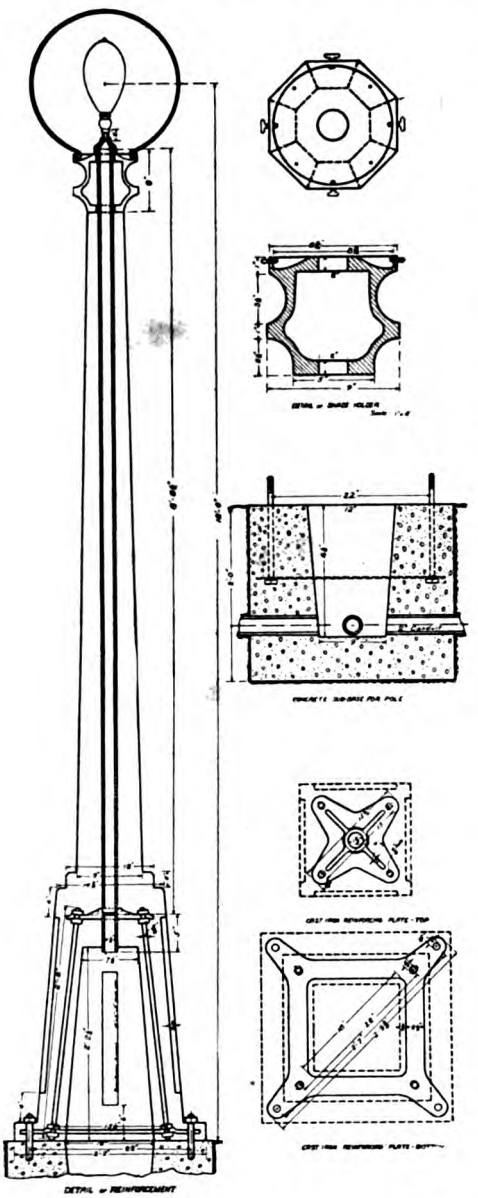
each lamp were completed prior to the arrival of the finished pole at its permanent location. By reference to the plan it will be evident that the construction enables easy and quick work on the electrical connections, without detracting from the beauty of design. The erecting frame and wagon were made at the University shop. The truck supports a weight of sufficient magnitude to require special construction.



UNIVERSITY OF WASHINGTON CONCRETE ELECTROLIER.

(Design by Frank E. Johnson.)

The University power-house generates and transmits electricity at 2300 volts to the centre of the manholes and subway type transformers, where it is stepped down to 225 volts at the lamp base. On the majority of the poles 100-c.p. Colonial Mazda lamps with 20-in. sand-blast finish globes are placed. These lights carry a voltage of 17.9, and in addition a few 200-c.p. lamps carry a voltage of 35.9.

The handhole in the concrete base is situated on the opposite side from the passing pedestrian, and the three corresponding, or symmetrical panels are of concrete, but painted black for harmony. A rich cement finish containing lamp black was experimentally used for this purpose.

The city of Seattle cluster-light pole system adjoining the campus shows the concrete standards in favorable contrast to those of cast iron on the boulevard. While the appended costs have not been completely segregated, and slightly higher costs might prevail if the lamp posts were made under contract, nevertheless the advantages of the concrete pole are prominent.

Bare pole	$14.50
(Pea gravel, $2.80 yd.; cement, $2.65 bbl.)	
Average cost of erection, including horse	0.80
Pole foundation and anchors	6.00
Pole trimmings, lamp, globe, transformers, etc.	16.20
Labor, wiring pole, placing lamp, leveling, etc.	1.00
Cost per pole	$38.50

The bare cast iron poles on the boulevard cost about $38 each, and the trimmings and foundations for either type is practically the same.

The most unique design brought to my attention is found in the southern California concrete electrolier. It will be readily seen that the whole scheme embodies the character and history of the section, linking it with a pleasant street-lighting system. The several hundred poles are of two sizes and two designs, the one illustrated carrying three globes, and a uniform single globe-bearing shaft which is used in the residential section. The former appropriately recalls

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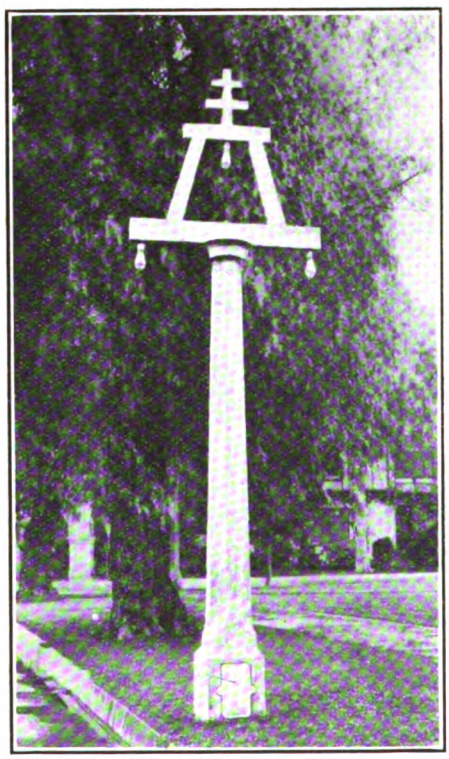
the historic Spanish era, as the top is the emblem of the early Franciscan padres who first settled in that valley. A belfry is plainly suggested by outline, but instead of the expected bells, the posts support three electric globes. Reference to the accompanying drawing will show that the pole is reinforced with either cupped or twisted steel bars of varying sizes, all securely bound with No. 10 galvanized wire. The portland cement concrete which encases the 1½-in. con-



FINISHED THREE-LIGHT CONCRETE ELECTROLIER AT RIVERSIDE, CALIFORNIA.

duit of standard black pipe is a mix of 1 part cement, 2 parts sand, and 2 parts good rock passing a ¾-in. screen and reject on ¼-in. screen. The specified plaster coat is 1 part each of portland cement and sand passing ½-in. screen.

The pole is set in a bed of 1: 3: 5 concrete 2 ft. square and 10 in. thick. The cross-arms are supported on a standard 11 ft. long, but the tip of the pole is some 4 ft. above, culminating in the attractive capital. The three-light electroliers, made and erected by contract, cost $32 each in place, the fittings bringing the total cost for each standard to $40. The one-light pole by contract price cost the city of Riverside $12.50 in place, or $17 for the complete unit. In the residential section the poles have staggered setting to secure even distribution with minimum expense. The same idea is carried out in street intersections with satisfactory results.

It is evident that the increasing use of concrete for lamp posts is not a notion and confined only to the Pacific Coast, as is shown by the Ionic concrete pedestals in use in Terre Haute, Indiana, and the larger number outlining the famous Lake Shore drive in Chicago. In the pole design adopted by the Chicago park commissioners a single large globe rests on a metal-capped substantial monolithic standard. They differ largely from the Seattle poles in that there are no large block bases above ground containing the electrical connections. As in the Seattle design, the rough finish produced by the eating action of the acid bath aided by the presence of bright pea gravel, a pleasing effect, now coming into extensive use, is secured. An iron mold and a sample of the concrete lamp post cast complete from the mold, after the Lake Shore pattern, were the centre of an interested, though changing, group of people at the cement show held in Chicago during the early part of 1911.

It is likely that the further construction of concrete lamp posts will come into prominence, especially in the high-class residence districts. They can be made any place with local materials by local labor, and where properly designed, constructed, and erected their presence stimulates local and civic pride.

These poles are 16 ft. high, measuring from the curb to the top of the 20-in. globe. The bare pole weighs about one ton and contains 15 cu. ft. of concrete. Unit pole cost follows:

Cement, 4¼ sacks	$1.90
Gravel, 8.6 cu. ft.	0.55
Granite screenings for surfacing, 1½ cu. ft.	0.15
Torpedo sand, 1½ cu. ft.	0.05
Reinforcement, 82 lb. at $0.02¼	1.85
Pipe, w.i., 21 ft. 2 in.	1.45
Labor at $0.30	4.75
Tools, molds, water, etc.	1.30
Total bare pole	$12.00

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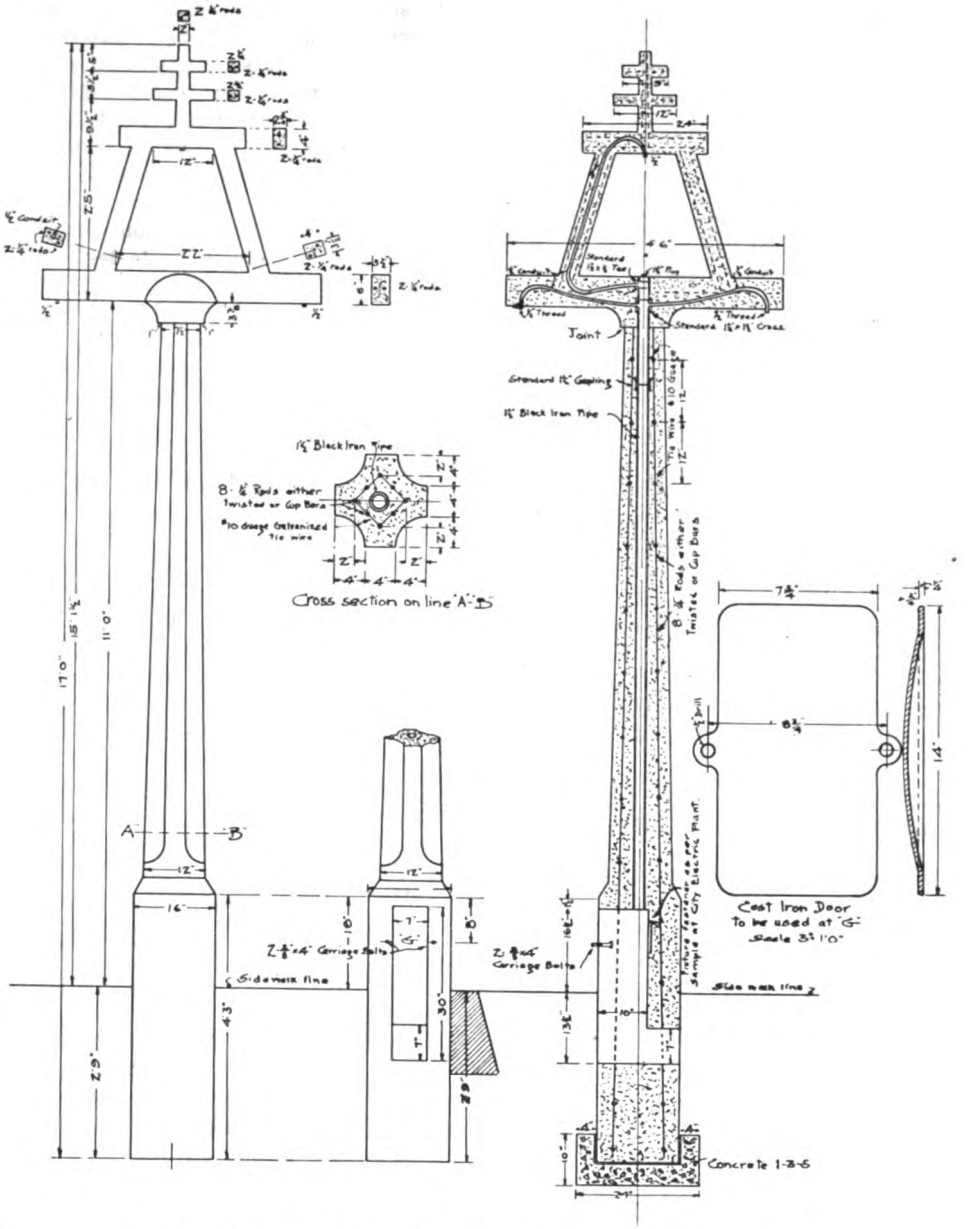
These posts were set in pairs, approximately 115 ft. apart and carried imbedded in a foundation of concrete 30 in. square and about 4 ft. deep, the pole being 6 in. above the bottom of the base. The costs for the electrical work varied, and depended largely on the distance from supply, and on interruptions caused by the construction of the sewer and other accompanying street improvements.



THREE-LIGHT CONCRETE ELECTROLIER, RIVERSIDE, CALIFORNIA.

(Copyright by Frank Miller.) A. P. Campbell, City Engineer.

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Society Meetings

The Sixth Congress of the International Association for Testing Materials will be held in the Engineering Societies' building, New York, September 2 to 7.

The International Congress of Applied Chemistry will visit the California oilfields on September 1, and will be taken over the Kern county fields as guests of the Kern Board of Trade.

Obituary

GEORGE MANSON HILL, member of the State Board of Harbor Commissioners, died at San Francisco on July 10, at the age of forty-five years. Mr. Hill was born in San Francisco June 22, 1867, and was graduated from the University of California in 1899. He was at one time superintendent of the Caribou mine in British Columbia and was also engaged in placer mining in Placer county. His engineering experience led to his being placed in charge of the engineering department of the Harbor Commission, a position of great responsibility and trust, in view of the large state bond issue for harbor improvements. Mr. Hill's plans and ideas for the benefit and improvement of harbor work were thorough and comprehensive, and his sudden death will leave a vacant place in the Harbor Commission that will be difficult to fill.

Commercial Paragraphs

The ALBERGER PUMP CO. has been awarded a contract by the Isthmian Canal Commission covering 145 pumps. These pumps are to be used in the miter gates at Gatun, Miraflores, and Pedro Miguel locks of the Panama canal.

ALLAN W. MARKS, formerly with De La Vergne Refrigerating Co., is now associated with H. W. Johns-Manville Co. as refrigerating engineer, with headquarters at the San Francisco office. Mr. Marks has had extensive experience in installing refrigerating plants for marine and other service.

The GENERAL PETROLEUM CO. has placed orders for the steel pump ends for its new pipe-line equipment with the George E. Dow Pumping Engine Co. of San Francisco. The steam boilers will be of the Heine water-tube type. Contract has been placed with the Llewellyn Iron Works of Los Angeles. The steam ends for the pumps will be compound Reynolds-Corliss engines and will be furnished by the Allis-Chalmers Co., of Milwaukee.

The C. L. BEST CO., of San Francisco, reports that its tonnage output has increased to such an extent as to necessitate a large addition to its present plant. Manganese, nickel, chrome, and vanadium alloy steel castings can be made from 1 to 10,000 lb. in weight. The services of Charles P. Bannon, who has had many years' experience in Eastern steel plants, have been secured as general manager. San Francisco sales offices are in the Sheldon building.

H. F. LYON CO., San Francisco, reports the following installations of Triumph ice machines for the past three months: One 5-ton refrigerating plant for the Royal Ice Cream Co., 1155 McAllister street, San Francisco; one 5-ton refrigerating plant for the Geo. Vestal Meat Co., Red Bluff, California; one 2-ton plant for A. Marty & Bro., Sacramento, California; one 5-ton outfit for Joe Fassler at Lathrop, California; one 25-ton ice-making Triumph shell brine cooler and ice tank, for the Pacific Fruit Cooling & Vaporizing Co., at Lodi; one 2½-ton plant for C. F. Schattgen & Son, at Angiola, California. The Lucerne Cream & Butter Co., of Hanford, California, has been using a 10-ton refrigerating plant for the past five years, and the Hanford Ice Co., of Hanford, California, has a 45-ton ice-making plant which has been running for the past three years, with the best of results.

Catalogues Received

ALLIS-CHALMERS CO., Milwaukee, Wisconsin. Bulletin No. 1626, 'Hydraulic Turbines.' 8 pages. Illustrated. 8 by 10 inches.

THE HAYWARD CO., 50 Church street, New York. Pamphlet No. 588, 'Hayward Buckets and Digging Machinery.' 8 pages. Illustrated. 6 by 9 inches.

A. L. IDE & SONS, of Springfield, Illinois, have issued bulletin No. 20, describing the Ideal Corliss valve engine. Much valuable engineering data is given in this bulletin as well as characteristic curves and valve diagrams illustrating the performance of this engine.

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